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FABRICATION AND ASSEMBLY OF A SHIPBOARD MULTIFUNCTIONAL WASTE I--ETC(U)
APR 79 F CROWSON, J A BYRNE, W W JONES

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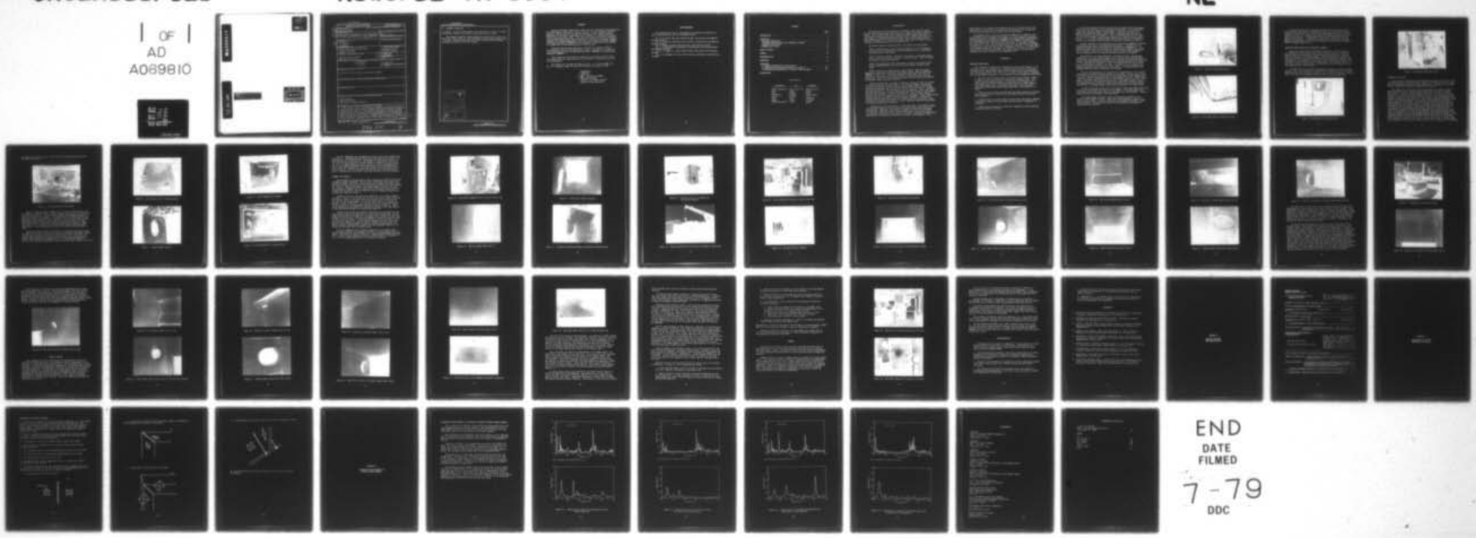

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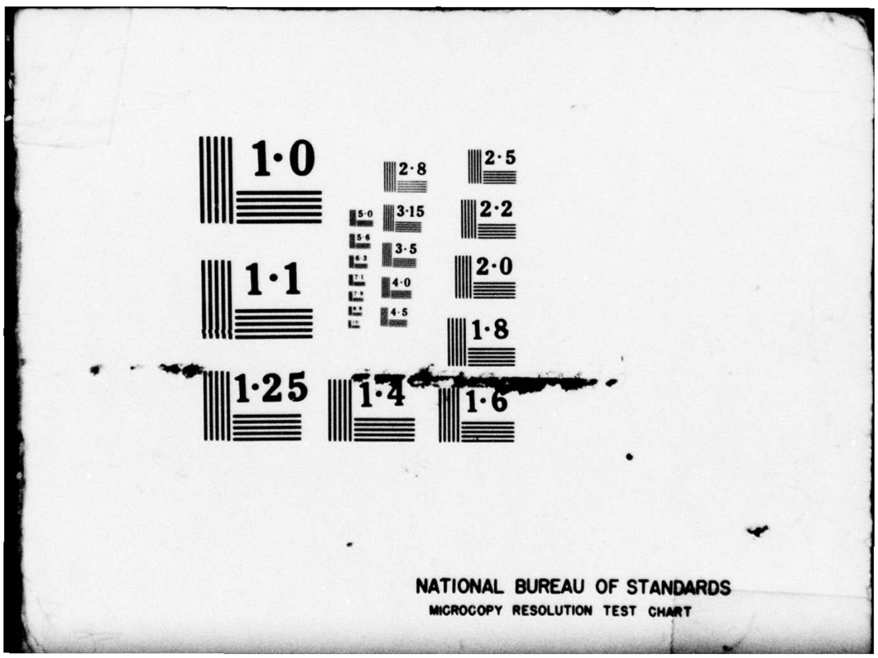
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This report details the fabrication, assembly, and burn-in testing of a multifunctional waste incinerator (MFI) designed by Vent-O-Matic Incinerator Corporation for Phase II of the Shipboard Incinerator Evaluation Program. Stress relieving and edge preparation were determined to be necessary for proper fabrication of metalwork, and adequate space and lifting equipment are major requirements during casting. Adequate facilities must be available for curing incinerator components since in situ curing to 2200°F was not cont

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20. ABSTRACT (Continued)

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attainable. The feed system appears very sophisticated in order to prevent overfeeding; however, only further testing will prove its value.

When properly operated, the MFI adequately handled trash, refuse, garbage, dense trash, waste oil, and fresh water sewage during preliminary burn-in testing. Problems encountered during burn-in testing will be further evaluated during the 1200-hr test program.

FOREWORD

Pollution abatement aboard Naval ships requires processing various materials including sewage, oily wastes, and solid wastes. The Environmental Sciences Branch of the Survivability and Applied Science Division, Weapons Systems Department was involved in fabrication and assembly of a shipboard multifunctional waste incinerator (MFI). This work was conducted as part of the Navy's Pollution Abatement Program under cognizance of the Naval Sea Systems Command (NAVSEA) with program management by the Naval Ship Engineering Center (NAVSEC). This report provides documentation for all phases of fabrication and assembly of the MFI and a brief discussion of preliminary tests.

Following the work described herein, the MFI will undergo a 1200-hr test program to characterize performance, safety, habitability, reliability, and maintainability prior to Technical Evaluation (TECHEVAL) and Operational Evaluation (OPEVAL).

The citation of trade names for commercially available products within this report does not constitute official endorsement or approval of the use of such products.

This report was reviewed and approved by Mr. S. V. Wyatt, NAVSEC and Mr. D. S. Malyevac, Head, Survivability and Applied Science Division.

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Mr. S. Seplow, Terminal Effects Branch, Environments Division

Mr. J. H. Westendorf, Photographic, Engineering, and Services Branch, Environments Division

Mr. J. C. Briggs Jr., Metal Trades Branch, Maintenance and Utilities Division

Mr. G. W. Bradshaw III, Metal Trades Branch, Maintenance and Utilities Division

CONTENTS

SI Conversion

Multiply	By	To Obtain
degree Fahrenheit	$T^{\circ}{}_{C}=(T^{\circ}{}_{F}-32)/1.8$	degree Celsius
foot	0.3048	meter
$foot^3$	0.02831	$meter^3$
foot/minute	0.005080	meter/second
gallon	3.785412	liter
inch	2.540	centimeter
pound	0.5436	kilogram
$pound\text{-}force/inch^2$	6895	pascal

INTRODUCTION

Environmental pollution abatement aboard Naval ships requires management of waste streams consisting primarily of sewage, oily wastes, and solid wastes. The multifunctional waste incinerator (MFI) concept was devised to provide an integrated and self-contained waste treatment system for ultimate disposal of shipboard-generated wastes. Such a system must process 450 gal of sewage in 12 hr, 375 gal of sewage and 1100 lb of refuse in 10 hr, and 225 gal of sewage and 600 lb of trash in 6 hr.

The Navy's program to develop an MFI is divided into three phases:

Phase I--Conduct basic research and development for a self-contained incinerator and manufacture a full-scale prototype unit to demonstrate the feasibility of the system.

Phase II--Design, engineer, fabricate, and deliver a land-based system for test and evaluation by the Navy at a Navy facility. Test the system to determine design deficiencies.

Phase III--Incorporate design improvements obtained from Phase II and perform TECHEVAL/OPEVAL testing on the final system on board a Navy ship.

Phase I efforts were completed for a Vent-O-Matic (VOM) Incinerator Corporation system by the Naval Surface Weapons Center, Dahlgren Laboratory (NSWC/DL) in June 1976. The major problem with the Phase I unit was its inability to structurally withstand transport between contractor and test facilities. After structural repairs were made, burning tests were conducted and the MFI concept was proven feasible.

Phase II efforts were initiated to develop a full-scale test unit using the data and observations from Phase I. The primary changes incorporated in the new design were modular construction of chamber panels, use of heavy refractory throughout, and increase of combustion area and volume. Changes were also required for certain features of each subsystem. Due to high levels of noise and vibration, a larger centrifugal heat fan running at lower speeds and utilizing acoustical shielding was selected. Smaller volume induced blowers were used for cooling and overfire air requirements. Minor modifications in burner controls were made to correct flameout problems. Selection of better grades of materials exposed to the more corrosive and abrasive areas was made to alleviate deterioration of those components observed during Phase I to be most susceptible to attack.

Functioning of the incinerator is relatively simple. The operator loads the ram feeder hopper with solid waste and actuates the feeding cycle with a pushbutton. The feeder door opens and allows the feed to be introduced into the main combustion system. After completion of the ram feed cycle, the feed door closes and a fresh charge can be made. Feeding is automatically controlled by an add/subtract counter on a preset timing sequence. With

these controls, the operator can charge up to 120 lb of trash within 5 min. Additionally, the ash door is interlocked with the feed cycle to open and allow the fresh charge to push residue into the ash drawer.

The VOM MFI Phase II unit was received at NSWC/DL on 22 February 1977 in accordance with the guidelines for Phase II of the Shipboard Incinerator Evaluation Program. Personnel from NAVSEC, David Taylor Naval Ship Research and Development Center, Annapolis (DTNSRDC/A), and NSWC/DL inspected the unit upon receipt and found structural deficiencies in the metal framework and refractory linings. Review meetings were held and the decision was made to modify the unit to achieve reliable structural integrity. A revised design was presented by VOM, and fabrication by NSWC/DL was initiated in June 1977 with technical assistance from VOM. This report details the fabrication, assembly, and burn-in testing of the redesigned unit.

DISCUSSION

METALWORK FABRICATION

The incinerator framework was redesigned to provide more support to the refractory, which was vulnerable to cracking caused by external vibrations and shock due to insufficient support from the side panels and anchoring system. The increase from a 1/8- to a 1/4-in. (3/8-in. on top panel) thickness for the side panels resulted in a few problems during the metalwork fabrication.

1. The 1/4-in.-thick steel plate, as procured through federal supply, is typically 1020 series steel and usually not perfectly flat. As a result of these characteristics, cold working of the flanges to original design radii and tolerances produced cracking at metal edges on the flange outer radius. To prevent such flaws, a more tolerable radius was selected and careful edge preparation was required on all panels.

2. Holes drilled at flange intersections and edge finishing by grinding were utilized to stress relieve the areas most affected by the cold work procedures.

3. To ensure that no surface defects existed after fabrication, magnetic inspection of bends and high-stress areas was used for acceptance of each panel.

4. Areas with full-penetration welds were inspected to detect possible cracking or defects in welds.

Since shell warpage and weld cracking due to thermal cycling was experienced on the original unit, the new design incorporates a 1-in. displacement on the door face with adequate reinforcement. Structural channel, full-penetration continuous welds, and additional refractory were utilized to reduce stresses on the feed opening. Heat is dissipated from the feed door by air cooling through a flexible hose connection to the cooling air jacket suction. A. P. Green stainless steel anchors were welded in the specified pattern and orientation which provided the necessary structural integrity.

Welders assigned to the fabrication were qualified by DTNSRDC/A according to procedures set forth in MIL-STD-248C (Reference 1). Approval for the welding procedure and the qualifications are presented in Appendix A. Two welders were qualified in this manner to ensure back-up capabilities throughout the project. Fabrication of the base was initiated on the assumption that no delays would be incurred during qualification of the welders.

Fabrication of all major metalwork, including the base, the four main chamber walls, the four sewage chamber walls, and the three interchangeable roof sections was completed according to the drawings and instructions provided by VOM. The base was fabricated using 4-in.-wide-flange beams on all sides, 4-in. T-beams equally spaced 15 in. apart for support struts, and a 3/8-in. mild steel plate for the top of the base. Holes 1 1/4-in. in diameter were punched around the base perimeter for ventilation. Full-penetration 1/4-in. minimum welds were used in fabrication of the base.

The side and end panels were fabricated by drop-shearing a 1/4-in. mild steel plate to include sufficient material for flanges. Corners were drilled at intersections of the flange ends, and the corner pieces were removed using a saw-cut. The 90° flanges were bent to approximately a 3/8-in. inside radius using a Cincinnati press brake with a 1/4-in. radius upper die and a 3/4-in. radius lower die. The resulting corner prior to welding is shown in Figure 1. All sharp edges were rounded to relieve high-stress areas that occur during the bending. The sewage chamber panels were fabricated in the same fashion.

To prevent stressed areas on the front panel, cutouts were made by drilling corners and saw-cutting the sections to be removed. The feeder door frame was welded to the front panel and all sharp edges were ground smooth. Figure 2 shows the lower left corner of the door frame.

The sewage chamber enclosure roof was fabricated by bending 1/4-in. plates to form channel sections. These were welded together at mitered corners to form a frame. A 3/8-in.-thick plate was welded to the frame to complete the panel. Solid welds were used at all interfaces throughout the fabrication of this piece.

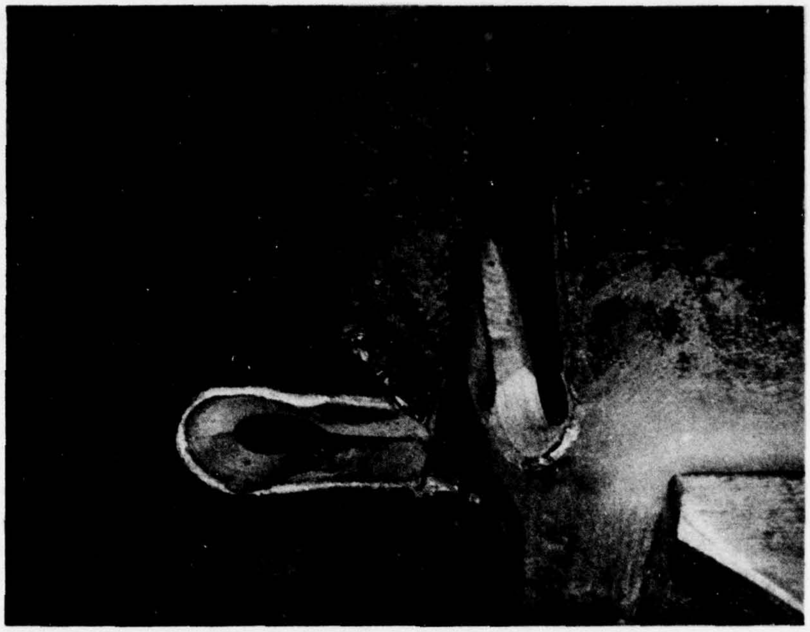


Figure 1. Detail of Corner Fabrication

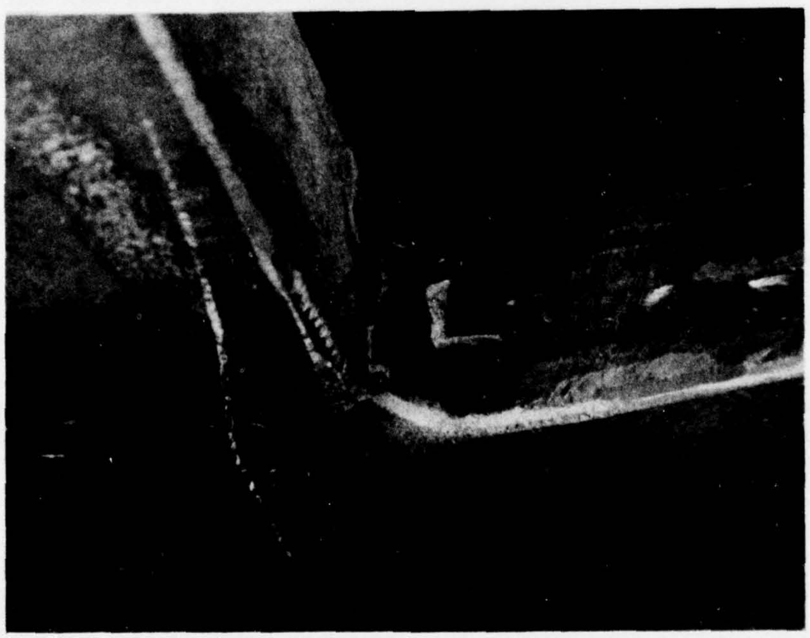


Figure 2. Corner Fabrication of Feed Door Frame

To ensure that the welds and bends required during fabrication were sound and free from defects, nondestructive testing in the form of magnetic inspection was performed on all welds and bends judged critical to the construction of the unit. Appendix B presents the procedures used and the results of the testing. All components tested were in accordance with MIL-STD-271E (Reference 2). Inspections were also made visually for surface geometry and soundness as well as for acceptance criteria based on NAVSHIPS 0900-LP-003-8000 (Reference 3).

STRUCTURAL MODIFICATIONS AND COMPONENT ALIGNMENT

During the review meetings preceding fabrication, it was decided that the afterburner section would remain in its original condition to obtain baseline data, with exception to the modifications necessary to interface with the redesign of the sewage chamber. These modifications included removal of the refractory around the entrance to the afterburner section, and the adoption of an elliptical rather than a square entrance to prevent stress cracking at corner configurations. Additionally, the refractory edge on the outlet of the afterburner duct was dressed with fresh refractory to prevent deterioration in this region.

To ensure that the fabricated components were within the required tolerances, a trail fit-up was made of the structural components and the existing feed door frame and afterburner section prior to initiating casting. Figures 3 and 4 illustrate the assembled metalwork front and rear, respectively.

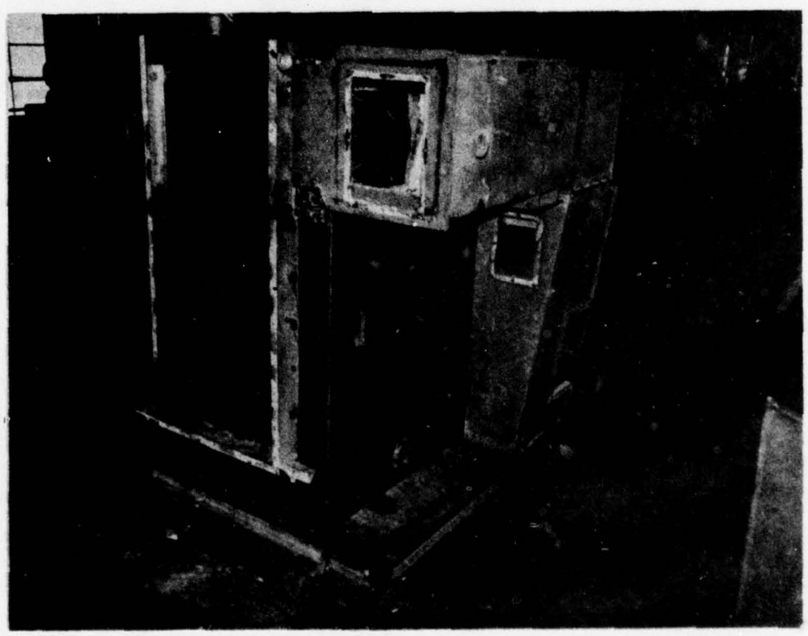


Figure 3. Metalwork Fit-Up (Front View)

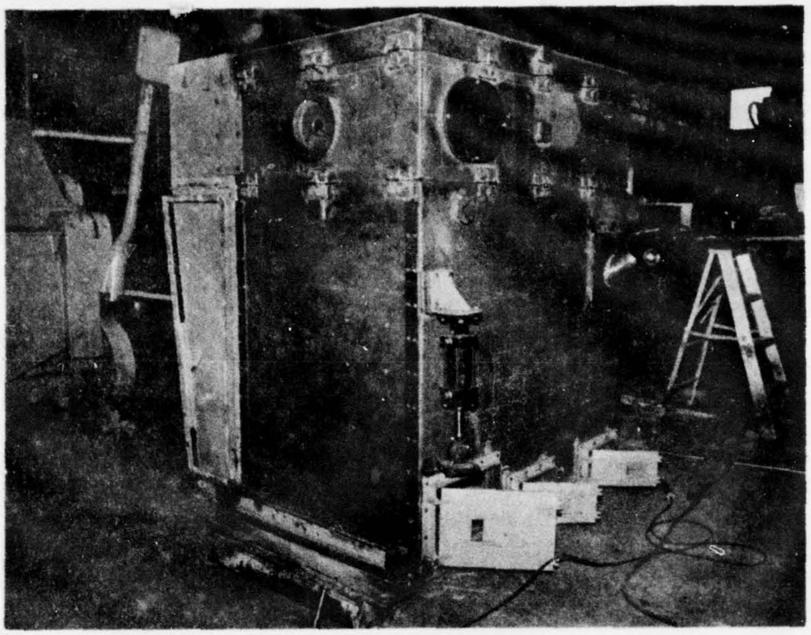


Figure 4. Metalwork Fit-Up (Rear View)

FINISHING AND CASTING

All structural components were sandblasted and primed with 2.0 to 2.5 mil of Thurmalox 245 heat-resistant paint, and were finished with a coat of grey paint in accordance with MIL-E-15130C (Reference 4). Anchors were installed and were coated with beeswax in preparation for casting.

The layout for the casting of the various panels is shown in Figure 5. Wooden forms were used to ensure proper dimensions on all cast sections. Five types of refractory materials were used to cast the MFI (all are products of A. P. Green Co., Mexico, Missouri, U.S.A.). The layer nearest the metalwork consists of block mix, which is utilized as the insulating material between the shell and the refractory. The primary refractory employed, Greencast 97, was selected because of its ability to withstand the corrosive, high-temperature environments. Sairset was used as the sealant between the porous block mix and the Greencast 97 to prevent loss of moisture from the Greencast 97 during casting. Kast-O-Lite 30 was used around the feed door to withstand the abrasiveness encountered during the ram feeding cycle. Jade Pak 88, a plastic refractory, was employed for the sewage nozzle billet and the impingement wall of the sewage chamber. This material should withstand the conditions of liquid impingement encountered during saltwater sewage processing better than the refractories used in other parts of the system. Figure 6 shows the initial cast of the 1 1/2-in. layer of A. P. Green block mix installed on standard A. P. Green stainless steel anchors. Sairset sealant was applied to the block mix layer, and 3 1/2-in. of Greencast 97 refractory

was poured over the block mix. Kast-O-Lite 30 refractory was used around the feed door opening.

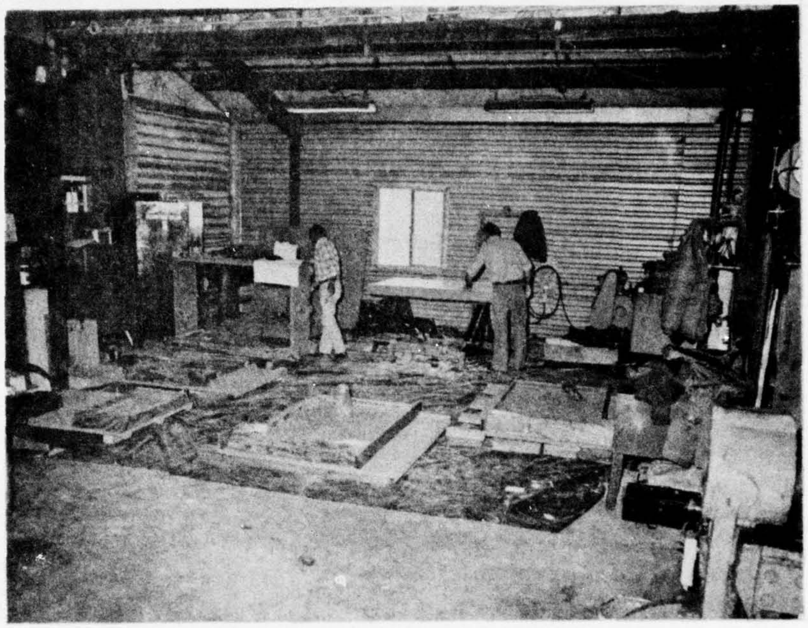


Figure 5. Casting Facilities and Layout

Figure 7 shows the sewage chamber walls: one wall partially cast, and the other wall completely cast. The oval-shaped exhaust port can be observed on the fully cast wall. The cast firebox module was assembled as shown in Figure 8 to check for alignment. The forward wall, the right (burner) side wall, and the rear wall are shown in position. The left side panel cracked diagonally when alignment pins were used to align bolt holes. The panel was recast within 2 hr and after curing, was refit to the module. A small crack about 6 in. in length occurred again upon assembly across the upper right corner. This crack was small enough to be patched with Greencast 97 fines.

Before the sewage chamber was installed, the Jade Pak 88 plastic refractory was cured for 28 hr, during which time the temperature was raised 50°F/hr to 700° with three hold periods (5 hr each) at 225°, 525°, and 700°F. The sewage chamber enclosure was covered top and bottom with insulating board, and the total assembly was wrapped with 2 in. of fiberglass insulation. Curing of the Jade Pak was performed using electrical heater elements (Figure 9).

Figure 6. Initial Cast of A. P. Green Block Mix

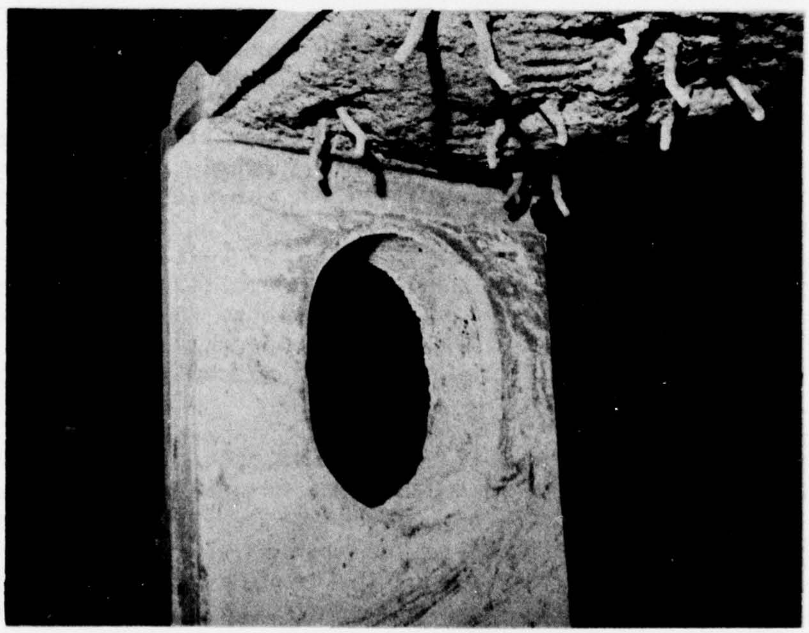


Figure 7. Sewage Chamber Casting

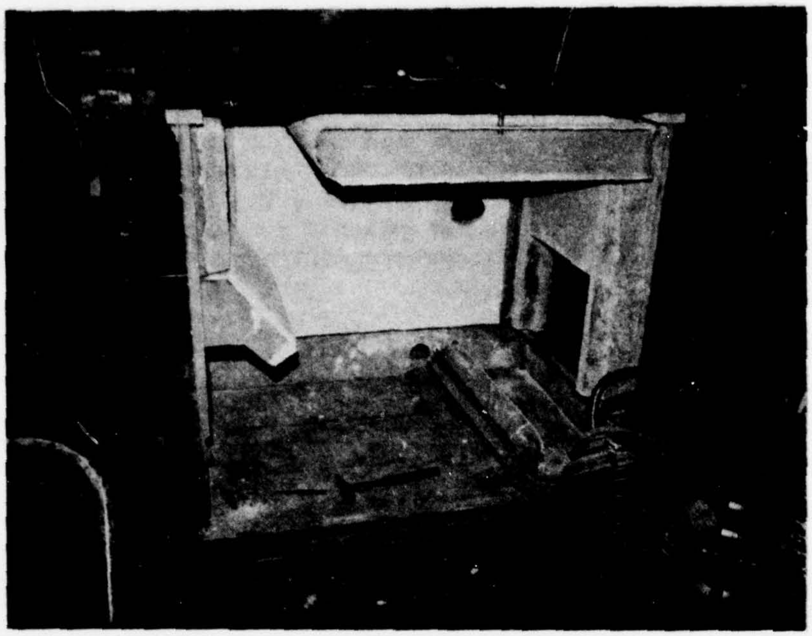


Figure 8. Partial Assembly of Firebox

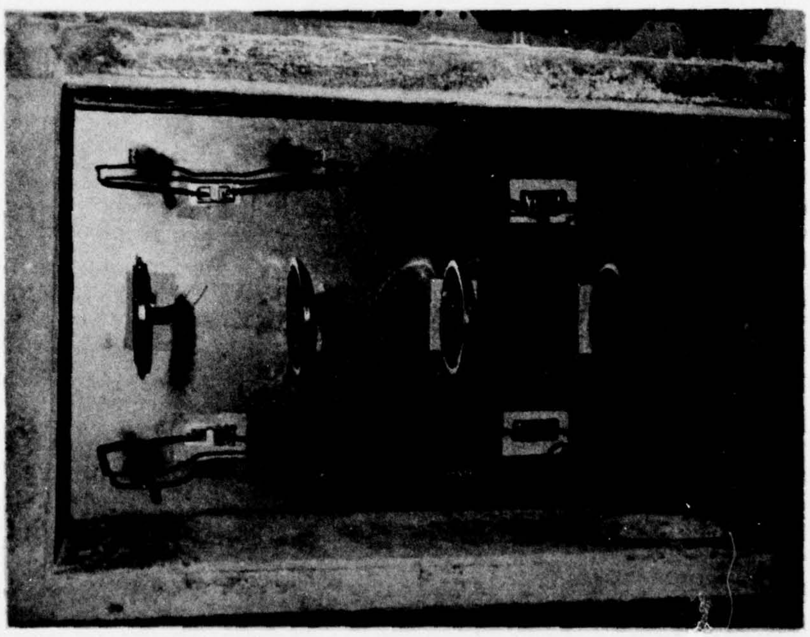


Figure 9. Heating Elements for Jade Pak Cure

The cast components were assembled and corner joints were finished with Greencast 97. Two additional top panels were also cast at this time in the same fashion as all other panels. The purpose of these panels was to test the vulnerability to vibration of two methods of anchoring the refractory: (1) the A. P. Green SS bolt-on anchors method is used in the existing unit; and (2) the NAVSEC Philadelphia design provides a sliding S-shaped anchor which allows the refractory to move slightly while still maintaining structural integrity. The two test panels are planned for vibrational testing prior to completion of the 1200-hr laboratory evaluation of the incinerator.

ASSEMBLY AND CURING

Upon assembly of the cast panels, metal flanges were sealed with gaskets of Fiberfrax paper insulation, and all outer flange edges were sealed with GE RTV103 sealant. The outer jacket panels were stripped of the old insulation and reinsulated with 1/4-in.-thick Carborundum Lo-Con felt with aluminum foil backing. The firebox module, the sewage chamber enclosure and roof, the afterburner chamber, and all jacketing were assembled to make ready for transporting the unit to the test sight for curing. Assembly required two riggers and a small jib crane.

Assembly of the unit was begun upon completion of the sewage chamber enclosure. Figure 10 illustrates the unit with the cooling jacket installed. The Jade Pak plastic refractory used on the sewage nozzle billet and the rear wall of the sewage chamber to alleviate deterioration by droplet impaction is shown in Figure 11, and the entrance to the afterburner section and the interior of the afterburner section is shown in Figure 12. Additional application of Greencast 97 refractory was made to the lower portion of the afterburner section as illustrated by Figure 13.

Transportation of the unit required fabrication of a spreader bar and load testing of the sling apparatus to a 10-ton safe working load. The assembly was hoisted by its base onto a flatbed trailer (Figure 14) and transported to the test site. The unit was weighed in transit and found to total 12,400 lb prior to curing. A crane was required to locate the unit at the test building (Figure 15). The incinerator assembly was then rolled into position with existing equipment in order to complete installation. The entire transport required four riggers, two heavy equipment operators, one 25-ton P-H jib crane, and a flatbed trailer.

The fully assembled unit is shown in Figure 16, an isolated picture of the flyash collector is presented in Figure 17, and the sewage nozzle assembly installation is shown in Figure 18. Complete photodocumentation made of the interior of the incinerator prior to curing (Figures 19 through 26) shows that all casting appears to be in excellent condition.

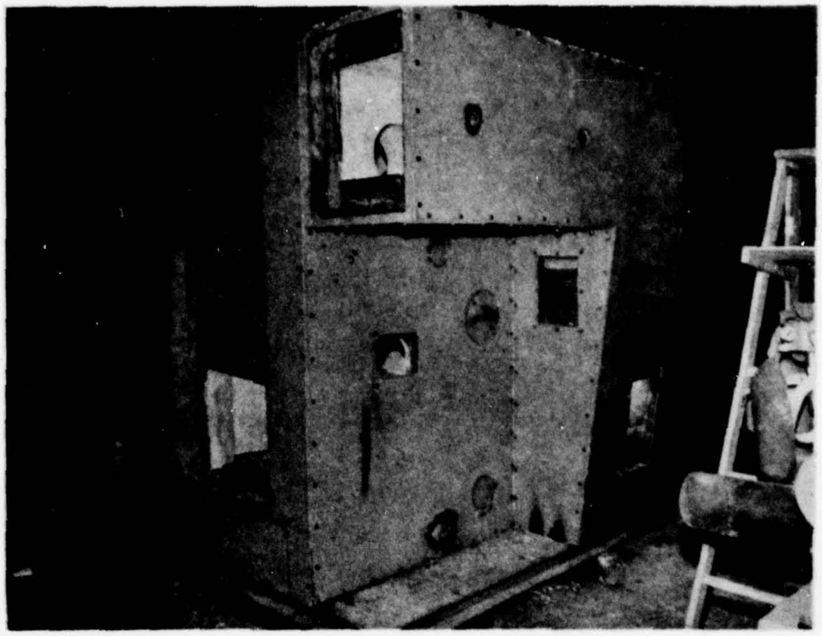


Figure 10. Incinerator Assembly Prior to Curing (Front View)

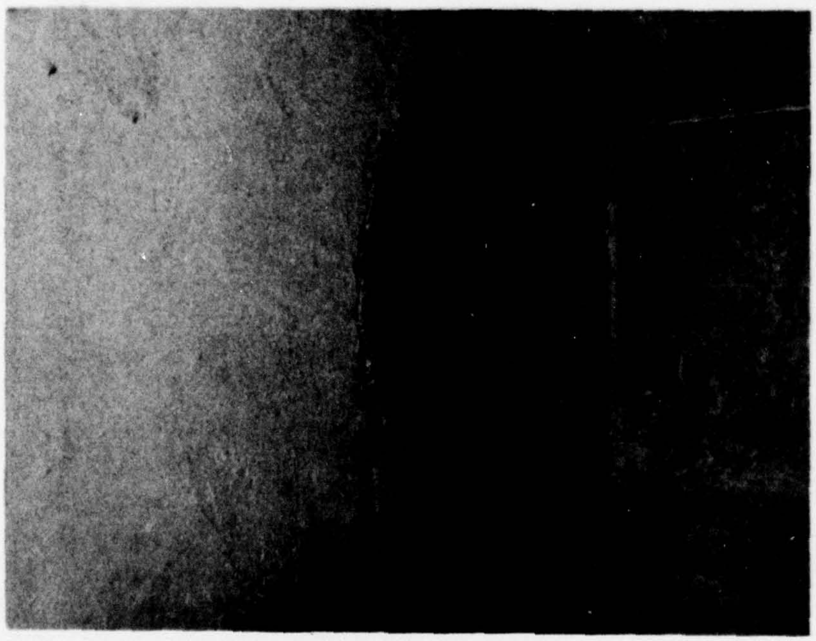


Figure 11. Jade Pak Sewage Nozzle Billet

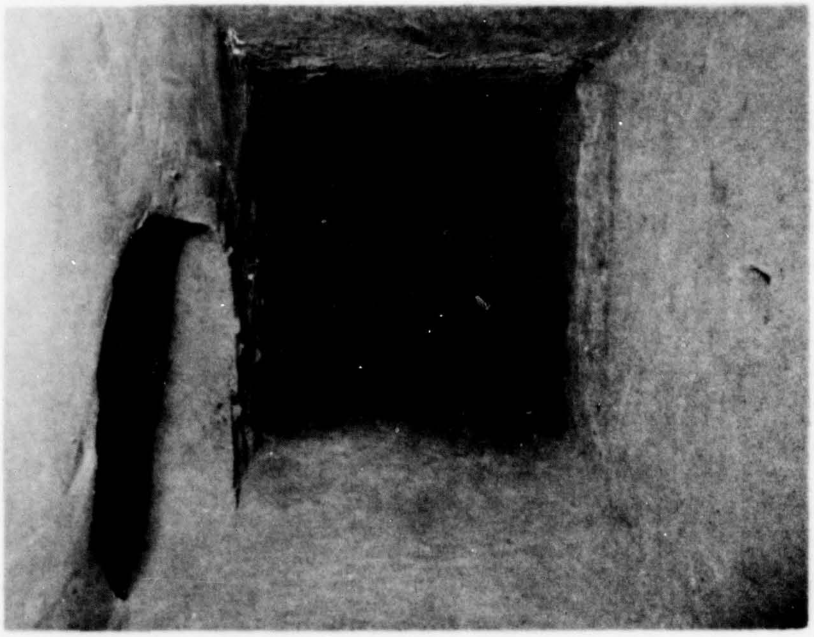


Figure 12. Afterburner Section Interior

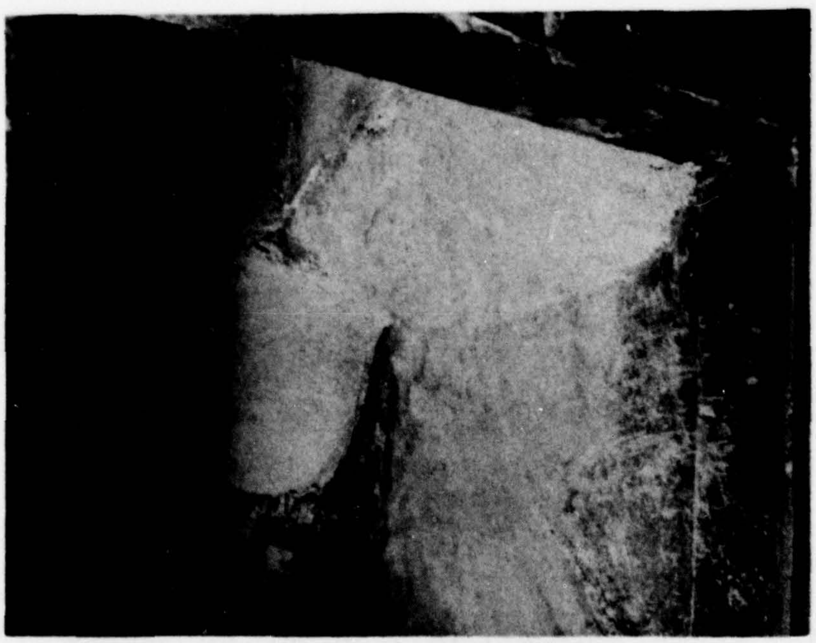


Figure 13. Dressing of Refractory Edge at Afterburner Section Outlet

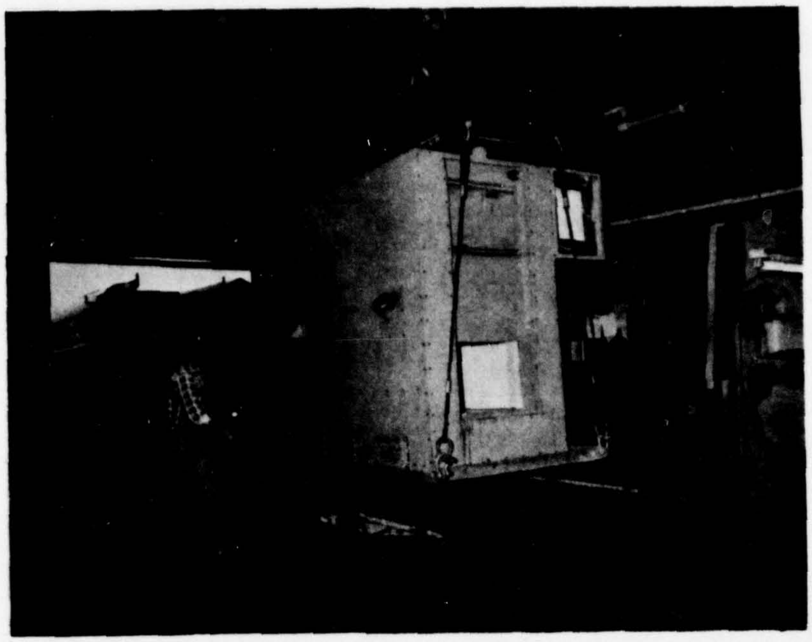


Figure 14. Flatbed Trailer for Transporting Incinerator Assembly

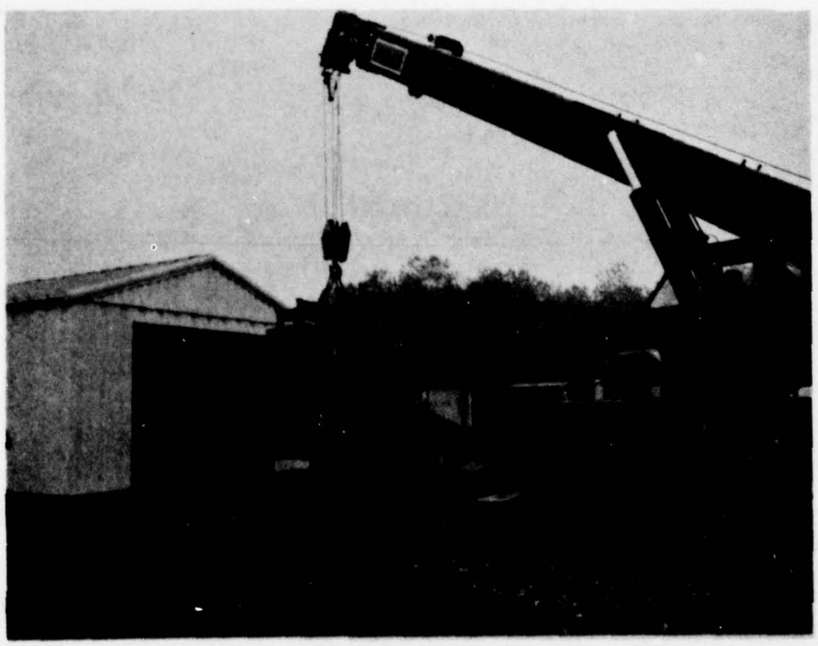


Figure 15. Delivery Operations of Incinerator Assembly at Test Site

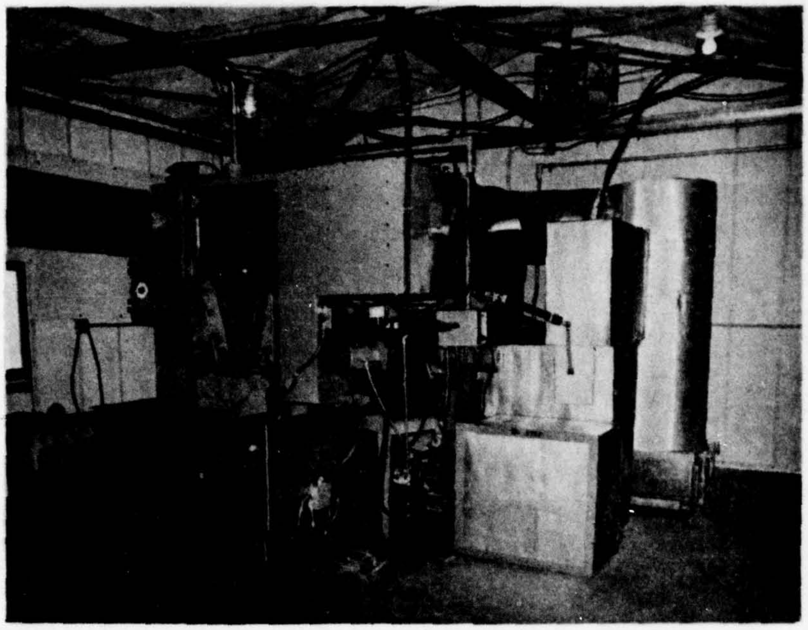


Figure 16. Fully Assembled Incinerator (Burner Side View)

Figure 17. Fly Ash Collector Assembly

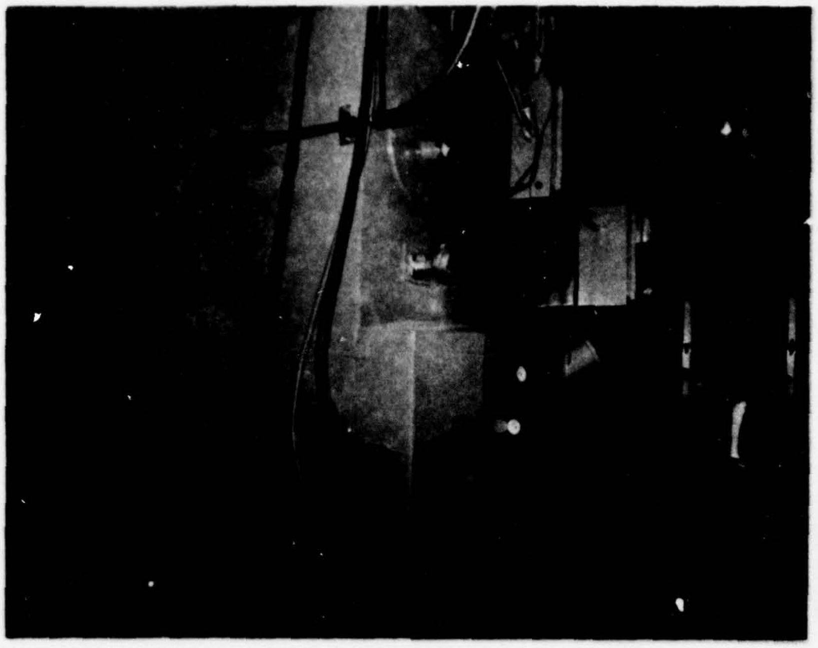


Figure 18. Sewage Nozzle Assembly Installation

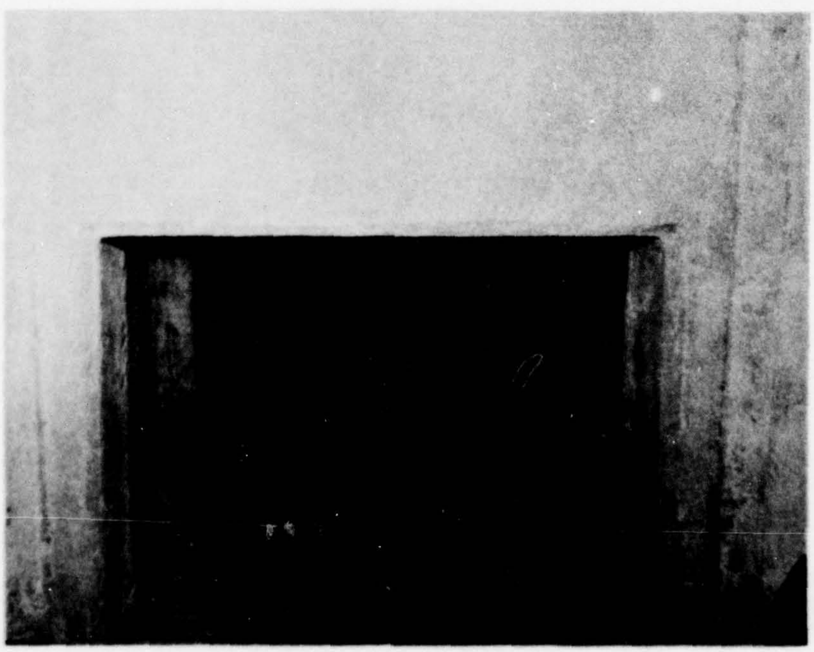


Figure 19. Forward Interior Wall of Firebox Before Curing

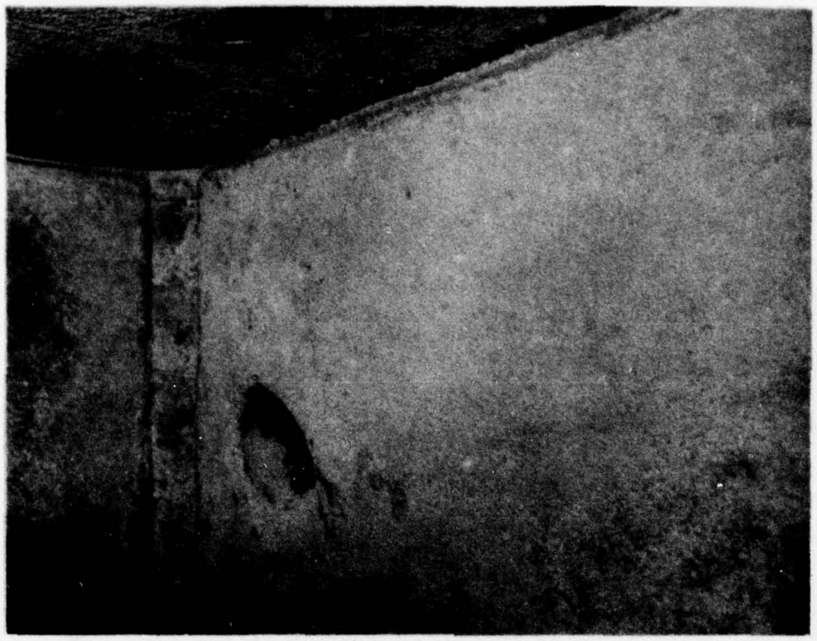


Figure 20. Left Interior Wall of Firebox Before Curing

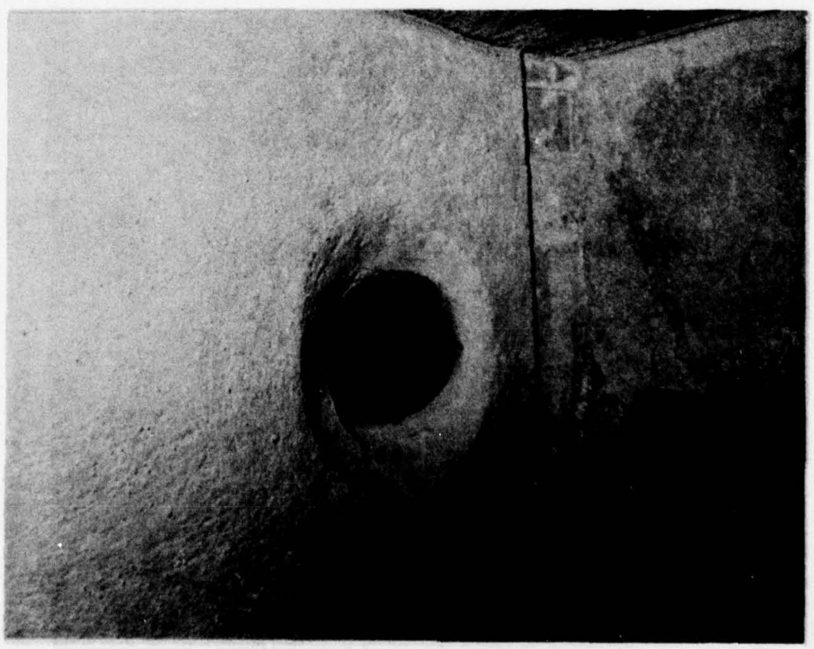


Figure 21. Right (Burner Side) Interior Wall of Firebox Before Curing

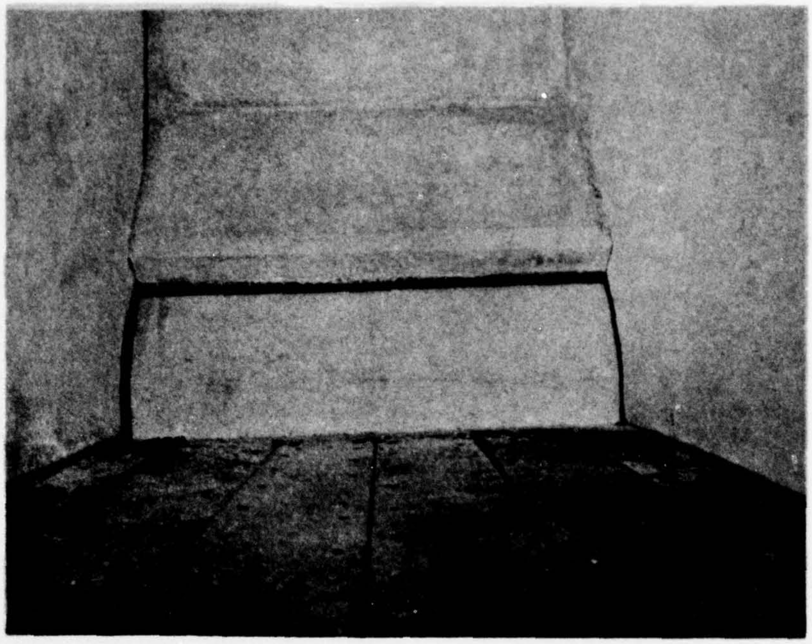


Figure 22. Ash Drawer Assembly Before Curing

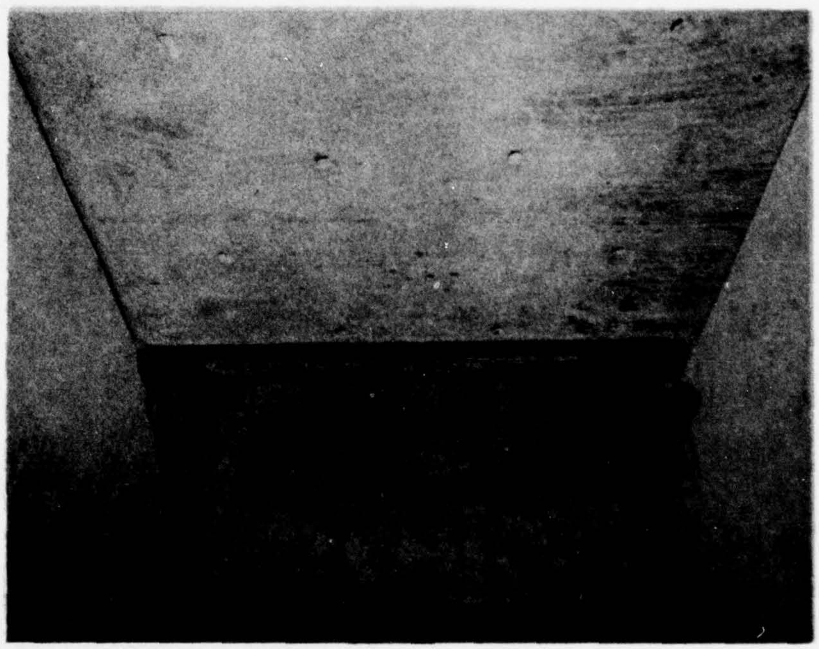


Figure 23. Firebox Roof Section Before Curing

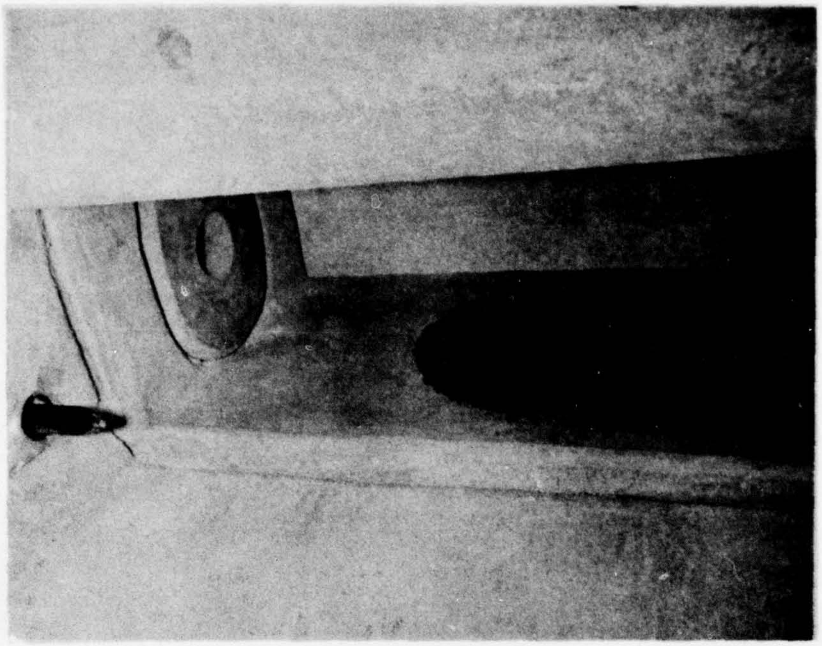


Figure 24. Entrance to Sewage Chamber Before Curing

Figure 25. Sewage Chamber Access Port Before Curing

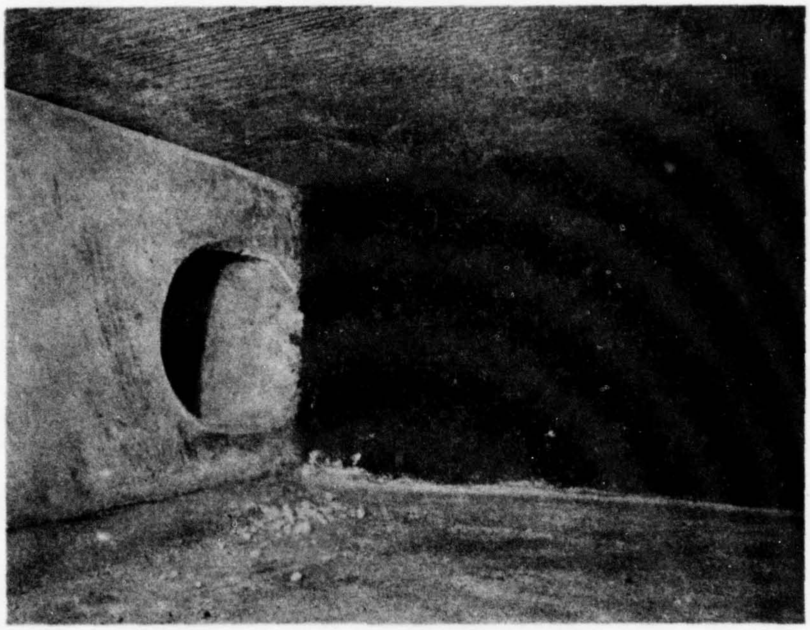


Figure 26. Jade Pak on Rear Wall of Sewage Chamber Near Gas Exit

The incinerator in situ and the extra sewage enclosure tops were cured simultaneously. The assembly used to cure the tops is shown in Figure 27. Lightweight insulating firebrick was used to construct the enclosure. Photographs taken before curing showed no cracking. Curing was performed in accordance with the manufacturer's recommended schedule; that is, the temperature was gradually increased at a rate of 50°F/hr with five hold periods (6 hr each) at 300°, 525°, 1025°, 1800°, and 2150°F. A small burner was utilized through the feed door to bring the incinerator to 300°F. Thereafter, the main burner and its controller were used.

The controlling thermocouple, which was also being used for a visual display readout, showed significant variance at higher temperatures (e.g., a 1600°F readout corresponded to a 2100°F firebox temperature). Induced draft fan and exhaust gas outlet temperatures were observed to be quite high. A temperature reading of 750°F at the induced draft fan, which is rated for 800°F, indicated that a 2200°F cure temperature in the afterburner chamber was unattainable. Consulation with the refractory manufacturer revealed that curing for 12 hr at 1800°F would adequately cure the refractory for the purposes intended even though complete setting of phosphate bonds would not occur. After 7 hr of cure at 1800°F, an audible thump was heard from the main chamber of the incinerator (the most extensive refractory crack observed is shown in Figure 28). During the final hours of the hot cure period, a malfunction in the fuel supply system caused an emergency shutdown for approximately 1/2 hr. After repairs were made, the incinerator was placed in the burndown mode to provide a controlled cooling of the refractory.

Figure 27. Assembly for Curing Test Panels

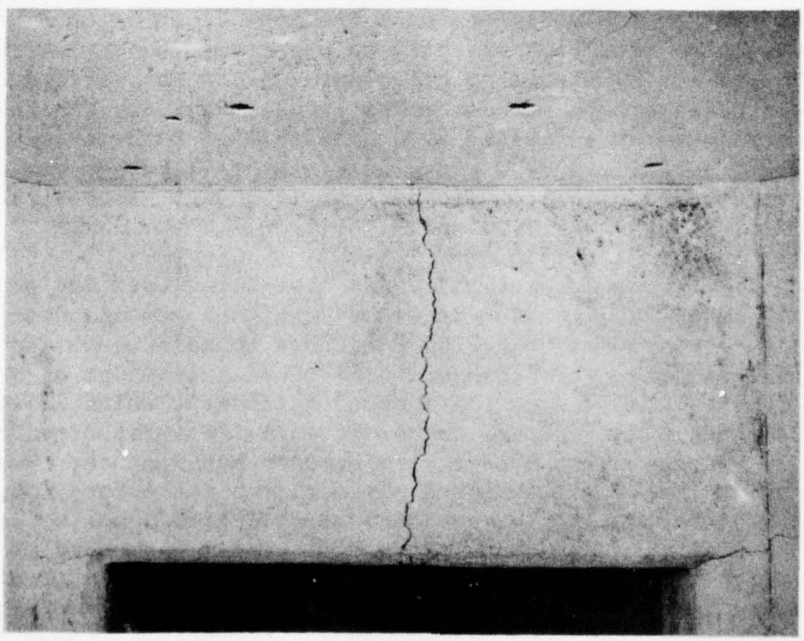


Figure 28. Cracking in Front Wall of Firebox After Curing

Upon completion of the 88-hr cure period, photodocumentation was again made of the incinerator interior. Figures 29 through 36 show the cracking of the refractory. Several cracks not exceeding 1/16-in. in width were observed primarily above the feed door and in the sewage chamber roof panel. Very minute hairline cracking was observed in the two extra tops (Figures 37 and 38). Figure 37 shows the top cast using NAVSEC Philadelphia design sliding anchors; and Figure 38 shows the top (identical with the top construction on the incinerator) cast with the standard A. P. Green SS anchors.

Figure 29. Left Interior Wall of Firebox After Curing

BURN-IN TESTING

After completion of the curing period, the induced draft fan was observed to be excessively noisy. Accelerometer tests were performed on the fan after an attempt had been made to quiet the unit by changing and rotating bearings. The results of these tests (Appendix C) indicate that peak acceleration levels occurred at approximately 50 and 200 Hz, as well as at harmonics of these frequencies. To assure that the blower would operate as quietly as possible going into the 1200-hr test, a new impeller, shaft, and bearing assembly were installed, which significantly reduced audible vibrations. The vibrations observed are intuitively felt to be a result of permanent distortion of the shaft and/or impeller at the high temperatures encountered during the cure period.

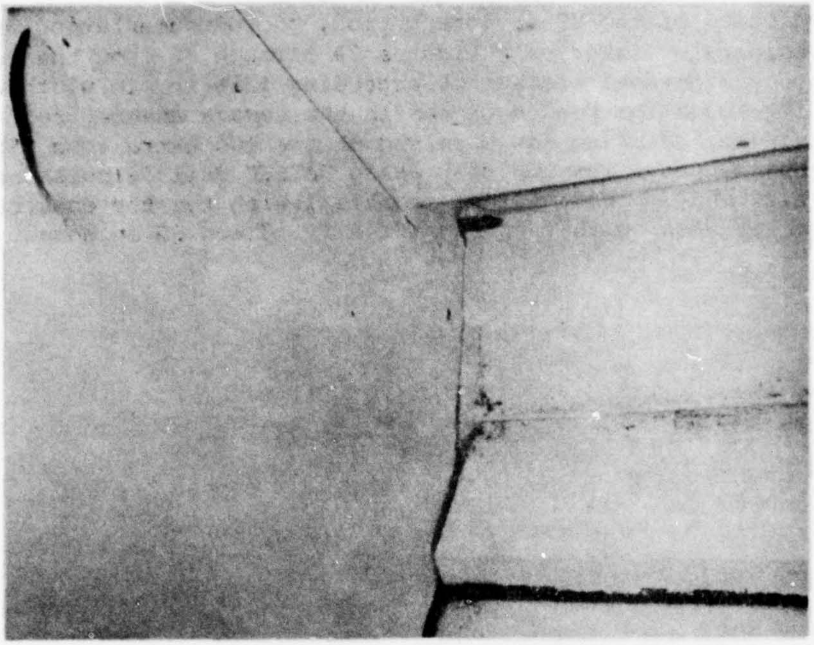


Figure 30. Ash Drawer Assembly After Curing

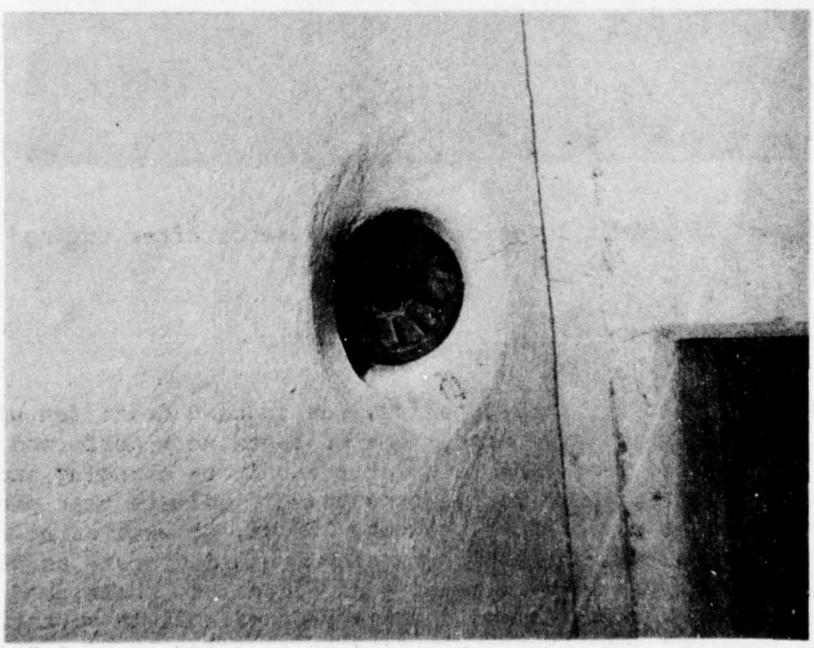


Figure 31. Right (Burner Side) Interior Wall of Firebox After Curing

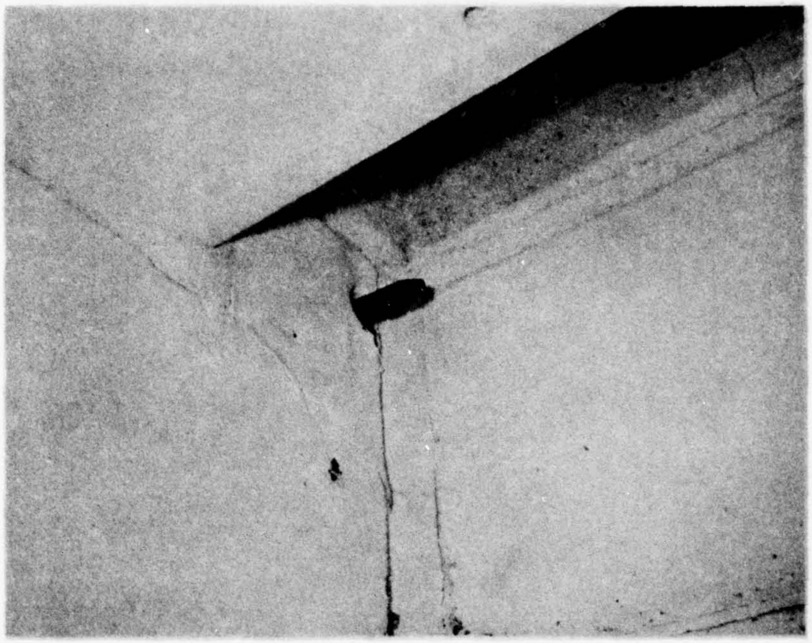


Figure 32. Entrance to Sewage Chamber After Curing

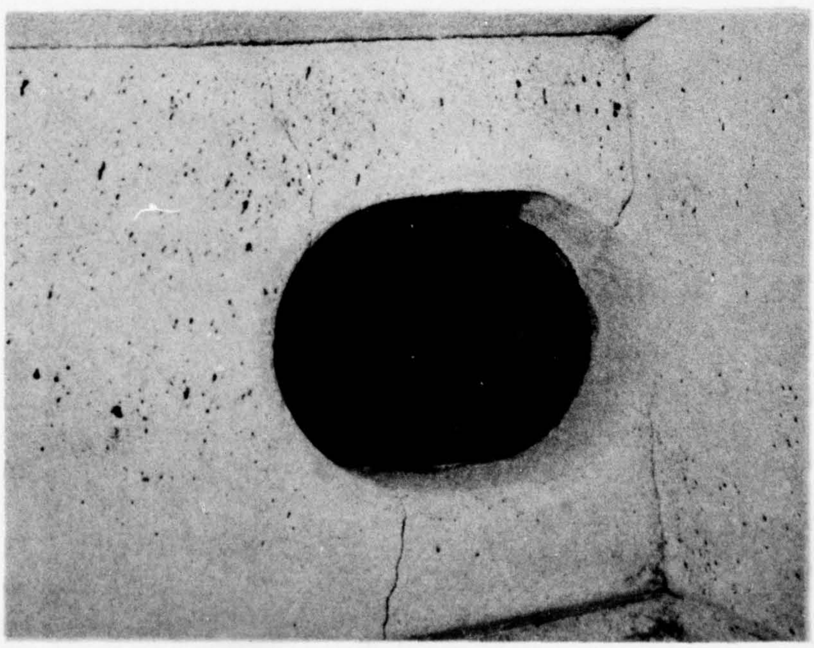


Figure 33. Sewage Chamber Access Port After Curing

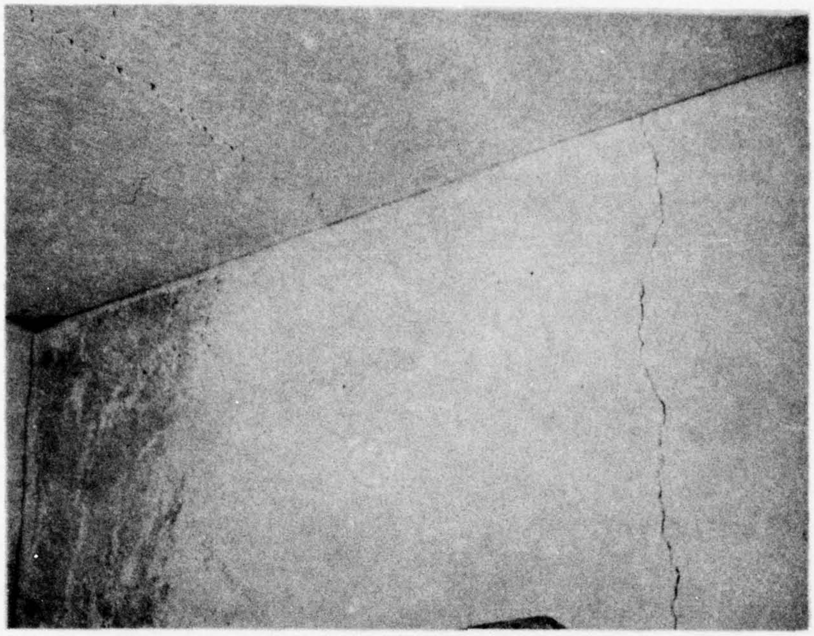


Figure 34. Right Wall of Sewage Chamber After Curing

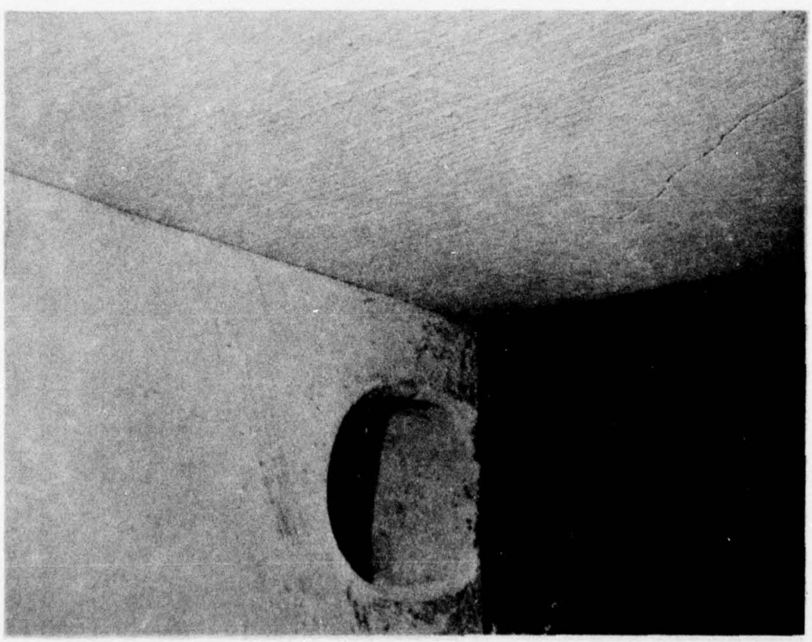


Figure 35. Jade Pak on Rear Wall of Sewage Chamber After Curing

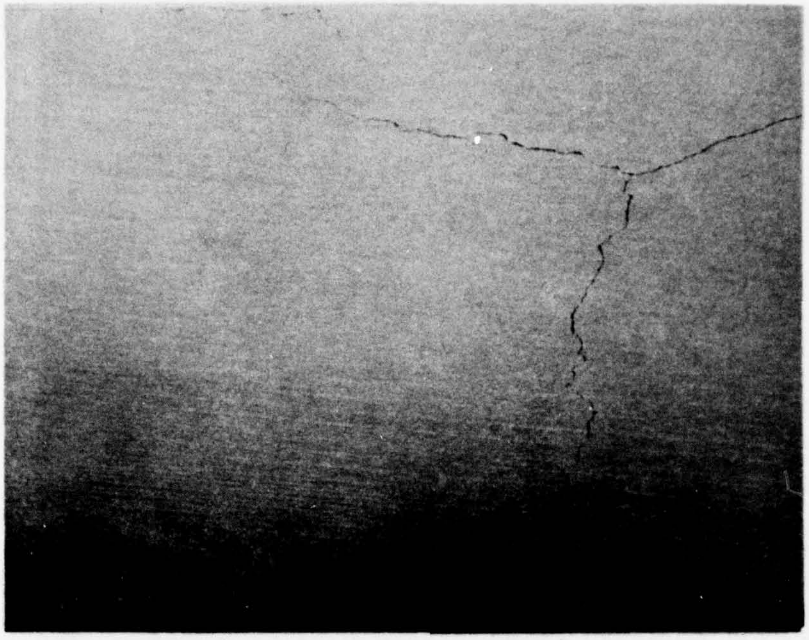


Figure 36. Sewage Chamber Roof Panel After Curing

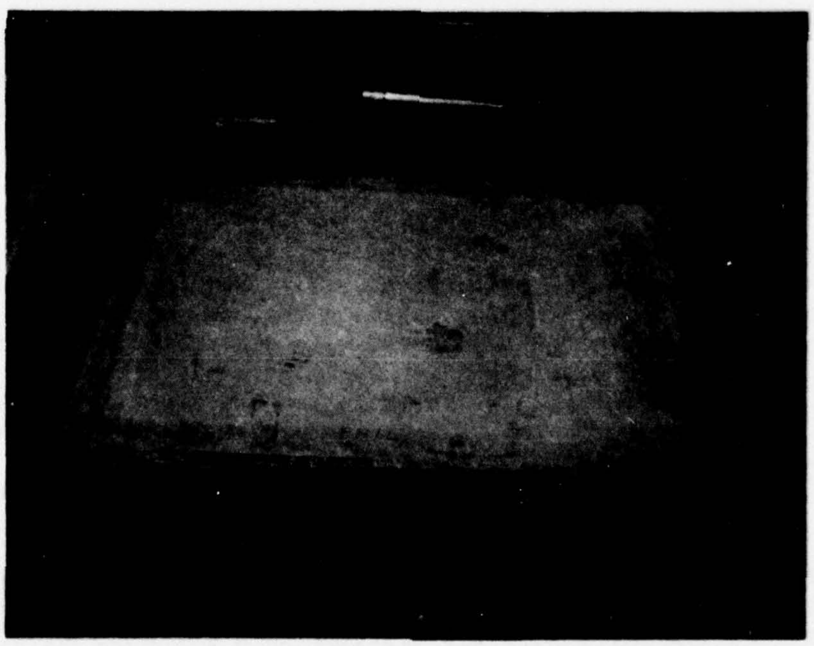


Figure 37. Test Panel After Curing (NAVSEC Philadelphia Anchoring)

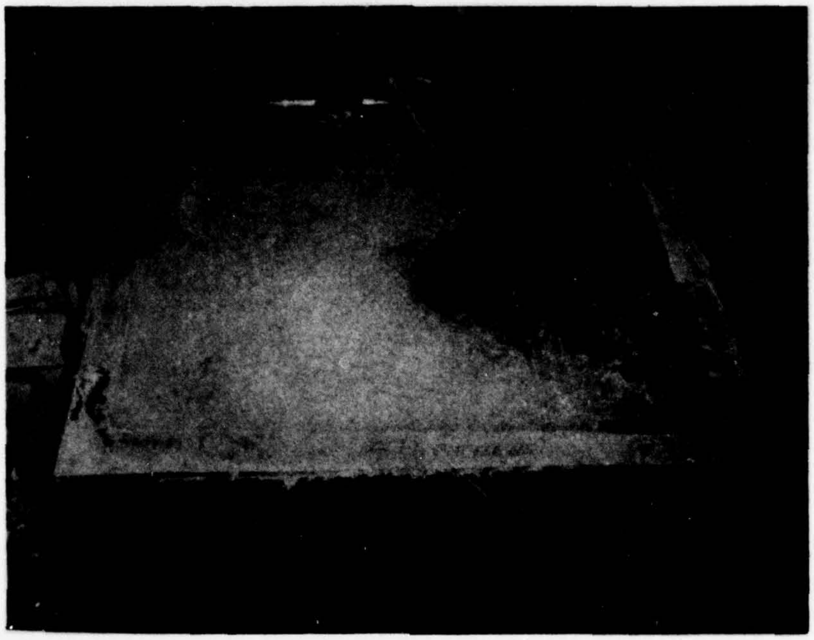


Figure 38. Test Panel After Curing (A. P. Green SS Anchoring)

Start-up of the system revealed problems in the pneumatics, feeder system, and materials delivery systems. The compressor originally installed to deliver 16 cfm and 175 psi of air was insufficient; thus, another compressor was installed that would deliver 25 cfm and 225 psi. An air leak developed in the feed door cylinder; therefore, new neoprene piston seals were installed. The new compressor proved adequate for operation of the incinerator; however, it was not capable of delivering the flow requirements for both the sewage nozzle and the Wager opacity meter mounted on the exhaust stack.

After obtaining the proper air requirements to the sewage nozzle, the spray pattern was observed to be quite wide. This resulted in liquid impingement on the nozzle billet and the side walls of the sewage chamber. The nozzle assembly was removed and a new nozzle with a narrower spray angle was installed. During this exchange, the nozzle assembly broke when torque was applied to remove the nozzle tip (the high temperatures apparently caused the threaded joints to seize). Teflon tape was used to seal the threads and prevent the seizure problem from recurring. To alleviate liquid impingement on the inlet port refractory, the nozzle assembly was extended approximately 4 in.

An add-subtract counter was installed on the feeder control system to reduce the possibility of overfeeding. When properly set for the type of feed being made, the counter limits the operator to a given number of feeds during a preset time cycle. Adjustments were made to prevent loss of counts when manual operation becomes necessary. Additionally, a jam alarm was removed

from the feeder door circuit to eliminate alarms activated during manual operation.

Preliminary tests showed a mechanical interference between the feed door and the open end of the feed chute at elevated temperatures. Modifications were made to the feed chute to provide a 1/4-in. clearance on both sides, which prevents further operational problems due to temperature effects or material buildup on the chute sides.

Problems, primarily due to water in the lines and subsequent freezing, were encountered with the material delivery system during the initial burn-in period. Heating tapes and insulation were installed to eliminate this problem. Segregation of water in the waste oil lines produced flameouts of waste oil on start-up. Operating procedures were established to drain the lines at the pump and recirculate waste oil through the burner to purge lines prior to initiating waste oil burn. This is accomplished by bringing the incinerator up to the set point on fuel oil then setting the limit at a lower temperature until the waste oil has cycled for approximately 2 min. The set point is then returned to the proper value and waste oil burning is commenced.

Burn-in tests conducted by VOM (reported in Reference 5) indicated quite adequate solid waste reduction, since feeds exceeding 200 lb/hr were burned without difficulty. Three preliminary tests were conducted by NSWC personnel as part of the training period in which trash and refuse were burned at an average rate of 127 lb/hr. Minor feeder jams which occurred were primarily due to the high percentage of noncombustibles (10 to 15 percent) characteristic of the on-station trash. Provisions were made to continuously monitor the gas temperatures within the sewage chamber and the induced draft fan. Maximum temperatures observed during the preliminary tests were 392°F on the fan and 662°F in the sewage chamber, both occurred approximately 2 hr after initiating burndown from a 1600°F set point.

Several flameouts occurred while waste oil was being burned due to the time required to establish an adequate recycle period. Because no alarm had been provided for flameout, the operator was not alerted to troubleshoot the fuel supply or burner system. Consequently, sewage sprayed directly on the refractory. To avoid this problem in the future, the alarm on the feeder circuit was moved to the flameout circuit; feeder jams are indicated with a red light.

Specific criteria to be followed during the 1200-hr tests are outlined by References 6 through 8, and are summarized as follows:

1. Grates and ash drawers are to be cleared of ash material daily before start-up. Operator time should be less than 5 min.

2. Manual stoking at 10-min intervals during the burndown period will be performed until a firebox temperature of 700°F is reached, at which time stoking will cease. This is required to stay within the 8-hr normal working day constraint.

3. Dense trash and pure garbage are to be stoked and levelled approximately twice hourly for no more than 1-min duration.

4. Trash and refuse is to be stoked at a rate of once per hour for no more than 1-min duration only if apparent that feeding is difficult due to firebox compaction.

5. The add-subtract counter system will be operated as follows for the feeds indicated:

a. Dense trash and garbage fed at 60 lb/hr in one hopper load.
b. Bagged trash fed in bags as available with doubling up on the lighter ones (5 to 10 lb). Timer is set at 5 min.
c. Loose trash fed in 20-lb charges with timer set at 10 min.
d. Refuse fed in 30-lb charges with timer set at 15 min.
e. The counter will be set at 5 at all times.

6. Emergency shutdown procedures are: switch to burndown and manually close valves on outside fuel supply lines.

Additionally, procedures described in the MFI Phase II Technical Manual (Reference 9), will be strictly followed in order to determine its adequacy.

Figure 39 exemplifies loading of the feed hopper with bagged trash as will be conducted during formal testing. Figure 40 shows the operator as he controls all functions of the MFI.

SUMMARY

Fabrication of metalwork using the plate thickness specified would be facilitated by the use of a better-grade mild steel that is more suitable for cold forming. Again, care must be taken to relieve areas of high mechanical stress that occur during forming by utilizing relief holes and edge preparation.

Adequate space and lifting equipment must be available for casting operations. An interfacial sealant is required between block mix and Greencast 97 when allowing the block mix to set. Ample facilities must be available for curing Jade Pak 88 to prevent cold flowing during other casting and handling operations. Heavy-duty equipment, special slings and spreaders, and adequate space and personnel are required for handling a fully cast and assembled unit. The present arrangement is inadequate for installation within the restricted confines of a shipboard compartment.

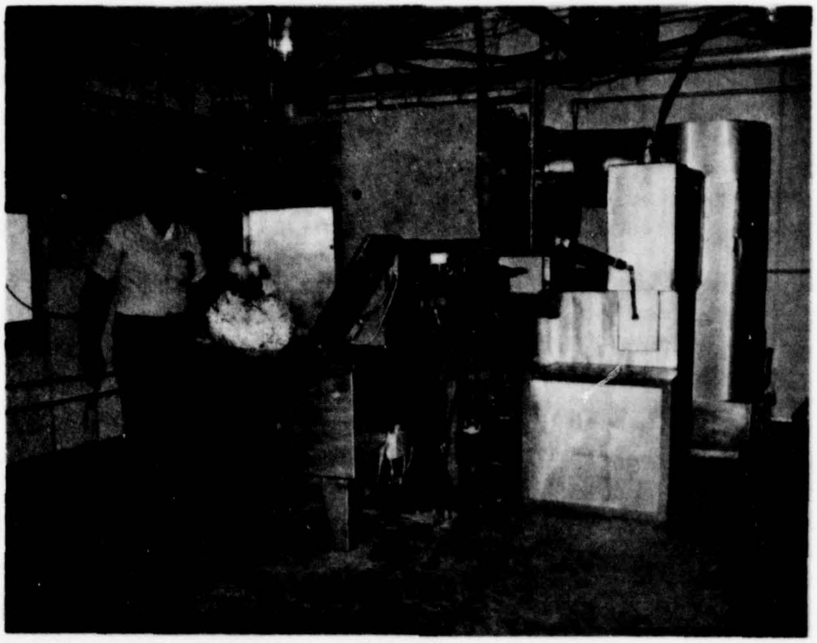


Figure 39. Operation of the MFI During Burn-In Testing

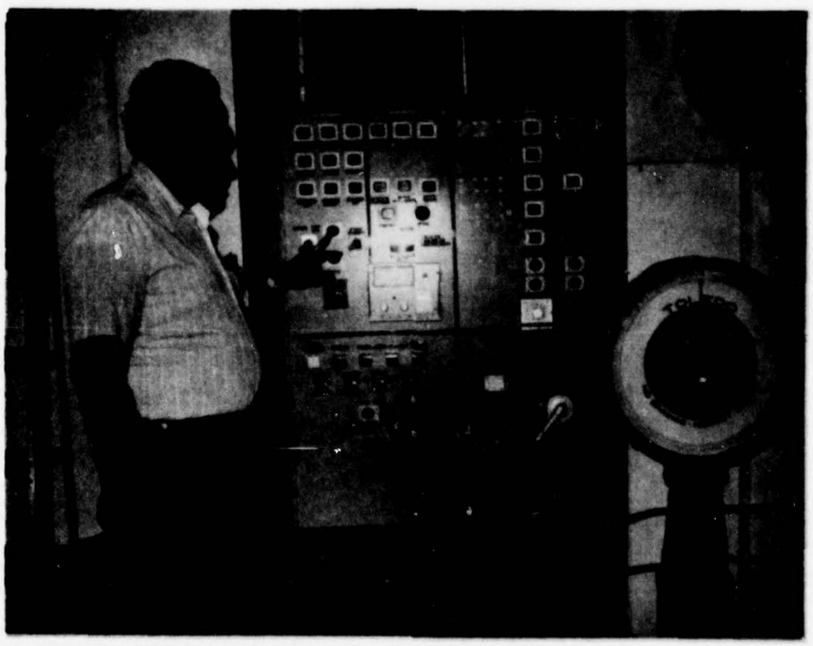


Figure 40. Incinerator Operator at Controls of the MFI

In-situ curing of the Jade Pak 88 plastic refractory to 2200°F in a fully assembled unit is not possible with the current equipment. If the present cure is insufficient for maximum material strength, future assemblies will have to incorporate pre-cured castings properly interlocked with other refractory materials.

Thermal stresses must be minimized to reduce severity of cracking in the Greencast 97 refractory. Additionally, uncured refractory must be handled with extreme care to prevent cracks from mechanical shocks and strains.

The feeder system appears too sophisticated for the simple function it performs--prevention of overfeeding. Only formal testing will prove the usefulness of its controls. Problems encountered during NSWC preliminary tests indicate that situations such as door jams, hopper fires, and ram jams occurred to the same degree as overfeeding.

The problem of overheating auxiliary components (i.e., the induced draft fan or burner assembly) during loss of power or emergency shutdown will occur unless high-temperature equipment and/or automatic bypasses can be provided.

The MFI adequately handled trash, refuse, garbage, dense trash, waste oil, and fresh water sewage during preliminary burn-in testing with minimal difficulties when properly operated. Problems discussed under the BURN-IN TESTING section are those that are anticipated to be typical during the 1200-hr formal test program.

RECOMMENDATIONS

1. Fabrication of future units or components of the existing unit should employ materials more suitable to cold forming. Additionally, care should be taken to ensure proper stress relieving on bends and corner cuts, as well as adequate welds.

2. Careful planning for equipment, facilities, and personnel to perform assembly should be made well in advance of shipboard installation. Alternatively, the previous concept of using smaller modular components should be considered.

3. Adequate curing procedures and schedules should be established around those used on the existing unit. Thermal cycling should be kept to a minimum.

4. The induced draft fan should be replaced with a unit capable of withstanding high temperatures. Until then, a lower set point of 1400°F will extend the life of the fan.

5. Careful scrutiny of the feeder control system should be made during formal testing to determine if its application is practical for the required function.

6. Components (i.e., the sewage nozzle) that may see high temperatures for extended periods should be assembled using antiseize materials to facilitate maintenance and replacements.

REFERENCES

1. *Welding and Bracing Procedures and Performance Qualifications*, Department of Defense, MIL-STD-248C, Washington, DC, 12 October 1973.

2. *Nondestructive Testing Requirements for Metals*, Department of Defense MIL-STD-271E, Washington, DC, 31 October 1973.

3. "Class 1, Pipe and Plate," *Metals Surface Inspection Acceptance Standards*, Naval Ships Systems Command NAVSHIPS 0900-LP-003-8000, Washington, DC, September 1967.

4. *Enamel, Ship, Exterior, Alkyd, Haze Gray Number 27, Formula Number 54*, Department of Defense MIL-E-15130C, Washington, DC, 10 January 1977.

5. *Development of Multi-Use Shipboard Incinerator, Phase II MFI Refurbishment Program, Final Report*, Vent-O-Matic Incinerator Corporation, North Quincy, Massachusetts, 20 March 1978.

6. *Progress Report, Engineering Technical Report No. 233*, Vent-O-Matic Incinerator Corporation, North Quincy, Massachusetts, 21 February 1978.

7. *Progress Report, Engineering Technical Report No. 235*, Vent-O-Matic Incinerator Corporation, North Quincy, Massachusetts, 28 February 1978.

8. "Field Test," Vent-O-Matic Incinerator Corporation Letter, North Quincy, Massachusetts, 21 March 1978.

9. *Preliminary Technical Manual: Operating Instructions--Maintenance Instructions for Vent-O-Matic Shipboard Incinerator Model MFI-2*, Vent-O-Matic Incinerator Corporation, North Quincy, Massachusetts, 28 February 1977.

APPENDIX A

WELDING PROCEDURE
AND QUALIFICATION

WELDING PROCEDURE
NSRDC/A Code 2821 Approved

No. *1*

for *Naval Surface Weapons Center*
Dahlgren Laboratory

Date *20 September 1977*
Proj. No. *Incinerator Fabrication*
Proj. Engr. *R. Juers*

Equipment and Location: *NSWC, Dahlgren, Virginia*

Process: *Shielded Metal Arc Welding (SMAW)*

Base Metal **(type and size)** Identification Date Available

1/8- through 3/4-inch-thick Carbon Steel

Backing Material: *Carbon Steel*

Electrode **(type, size(s), mfgr., heat, lot)** Date Available

1/8-inch diameter E 7018 (Jetweld LH-70)

Electrode Handling: *Use directly from freshly opened can. Store in heated holding oven.*

Joint Design, Welding Sequence, Electrode Size(s)

- *Butt and Fillet Welds.*
- *Flat and Vertical Welding Position.*

Preheat Temp. *Cool Temp (70°F min)*
Interpass Temp. *300°F max*
Voltage --
Amperage *120-150 amps: DCRP*
Travel Speed --
Heat Input --
Shielding Gas --
Flow Rate --

Joint Preparation Required: *see Special Requirements*

Inspection Requirements: *Visual plus M.T. of fillets and R.T. of butts if required by spec*

Special Requirements: *Plate surfaces in the way of welding shall be ground or grit blasted to clean base metal. Degreasing of plate surfaces shall be performed if required.*

(Welding procedures qualified in accordance with the requirements of MIL-STD-248C. Qualification data retained by Code 2821 DTNSRDC/A)

APPENDIX B

NONDESTRUCTIVE TESTING PROCEDURES AND RESULTS

NONDESTRUCTIVE TESTING PROCEDURE

1. The item to be inspected is a general purpose incinerator. It is fabricated from 1/4- and 3/8-in.-thick type 1022 steel plates welded together. The overall size is about 8 ft square by 7 ft high, less the flue heat exchanger. The incinerator is divided into four sections: base plate, solid chamber, liquid chamber, and top section. These sections are separable for ease of assembly and testing.

2. The type of magnetization to be used is longitudinally induced by means of a yoke. The yoke is to be placed in such a manner that the field lines run normal to the weld bead being inspected.

3. The equipment to be used is a Parker contour probe, Model DA-200.

4. The surface to be inspected is to be free of residues resulting from the welding process.

5. Parker Research type GP-5 white pigmented dry particles are to be used.

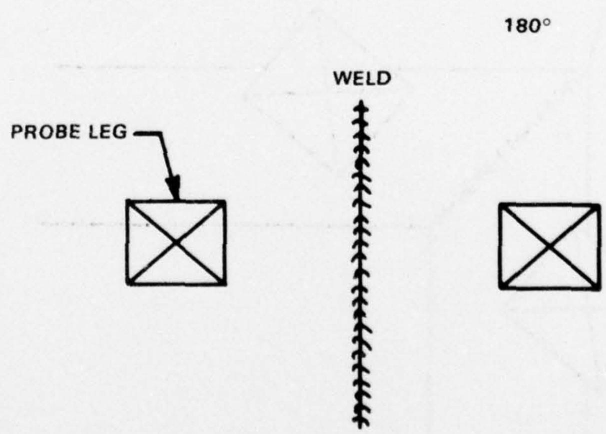
6. The continuous direct current method of magnetization will be used.

7. The magnetization current will be 4.0 A dc.

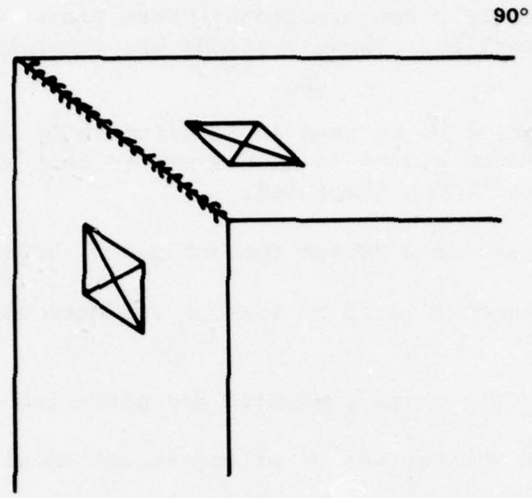
8. No demagnetization will be employed as there is virtually no residual field before or after testing.

9. The following sketches show the inspection grid to be employed with the various types of welds. In the case of welds of length exceeding about 3 in., the weld will be tested every 3 to 4 in. along its length.

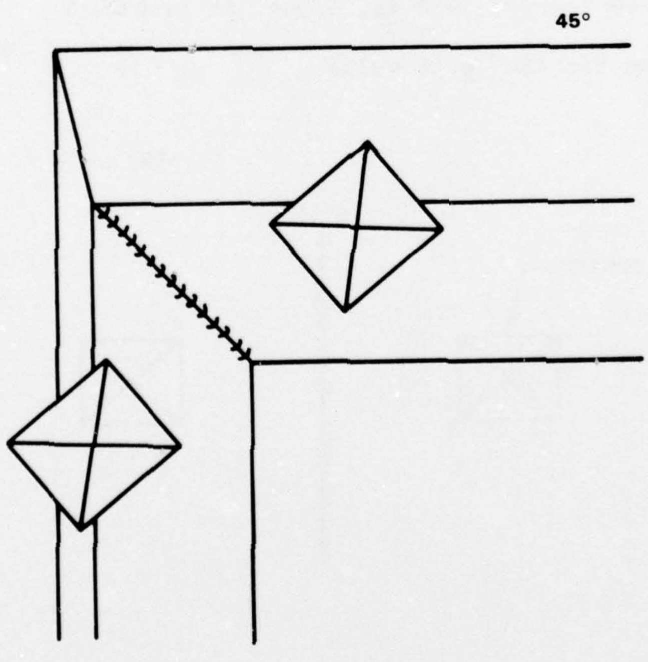
a. Probe location for 180° butt welds:



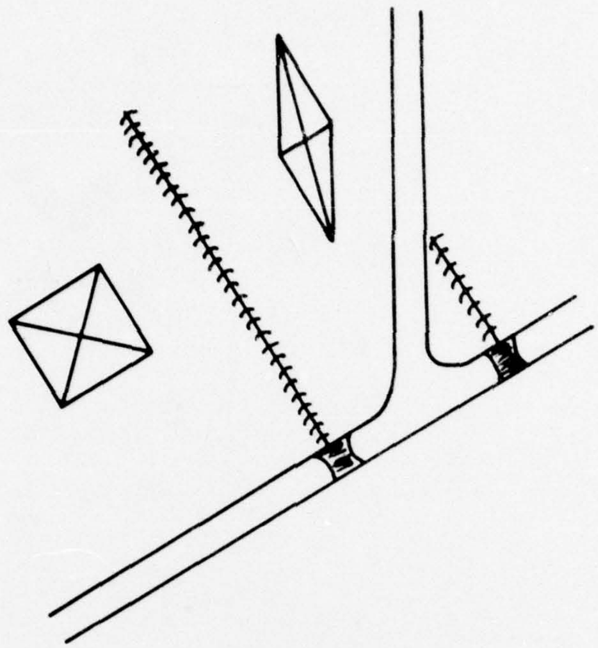
b. Probe contact location for 90° butt welds (location of probes are to be the same on the interior of the welds).



c. Probe contact location for 45° butt welds:



d. Probe location for interior welds of an I-beam or T-beam to a plate:



10. The multifunctional incinerator components met the above inspection requirements.

APPENDIX C

ACCELERATION MEASUREMENTS OF EXHAUST BLOWER ASSEMBLY

ACCELERATION MEASUREMENTS ON SHIPBOARD INCINERATOR EXHAUST BLOWER ASSEMBLY

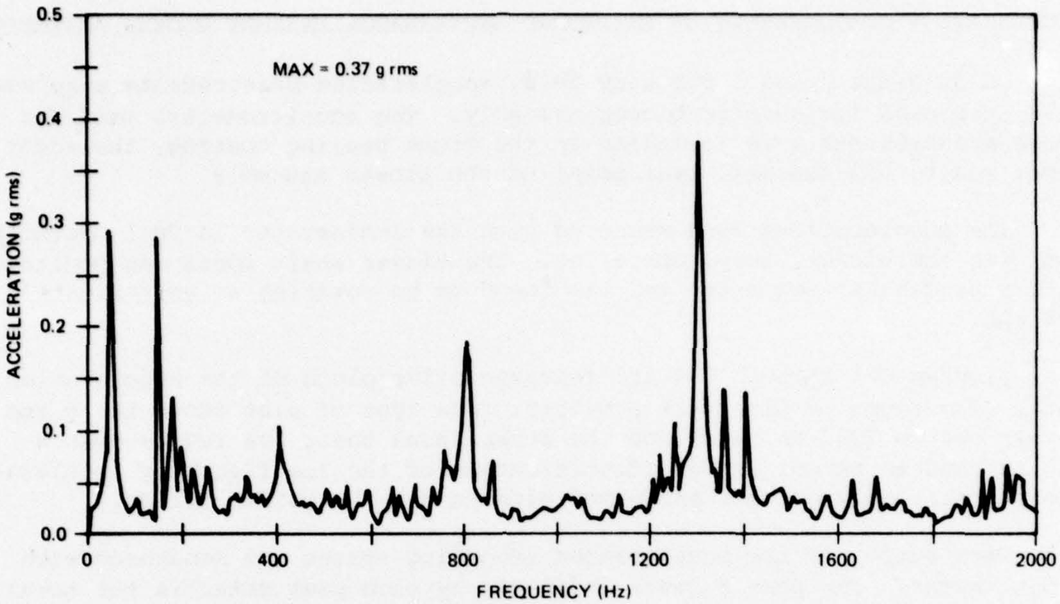
On 31 January and 1 February 1978, acceleration measurements were made on a shipboard incinerator blower assembly. The accelerometers used for these measurements were installed on the front bearing housing, the right front mount, and the left rear mount of the blower assembly.

The accelerations were measured with the incinerator in full operation and with the blower, only, operating. The blower shaft speed was monitored with a hand-held tachometer and was found to be rotating at approximately 300 rpm.

Figures C-1 through C-4 are representative plots of the acceleration data. Two types of plots are provided. One type of plot shows the g rms levels over a 2000-Hz band, and the other shows the g rms levels over a 500-Hz band to permit easier identification of the low frequency accelerations. All analyses were performed with an 8-Hz bandwidth filter.

Each output of the acceleration recording system was monitored with a peak meter. The peak g level indicated by each peak meter is the total of the acceleration components for all frequencies within the full range of the recording system. Therefore, the g levels for specific frequencies as plotted in Figures C-1 through C-4 will not be the same as the overall g level indicated by the peak meter.

The acceleration data indicated that there was a peak in the acceleration level at approximately 50 Hz. Because the blower fan had four blades, there was also a peak in the acceleration level at approximately 200 Hz. Additional peaks in the acceleration level occurred at harmonics of the 50- and 200-Hz frequencies. These results indicate unbalance in the shaft/impeller assembly, which was possibly due to shaft set on exposure to the excessively high temperatures encountered during initial burn tests.



NOTE: THE OVERALL g LEVEL WAS 2.55 g PEAK (1.8 g rms)

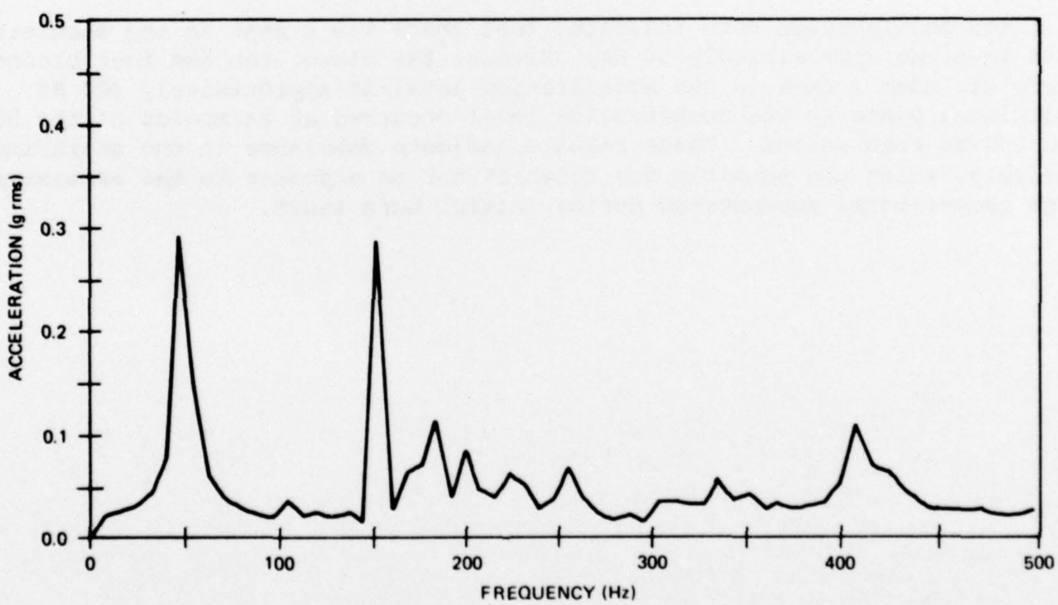
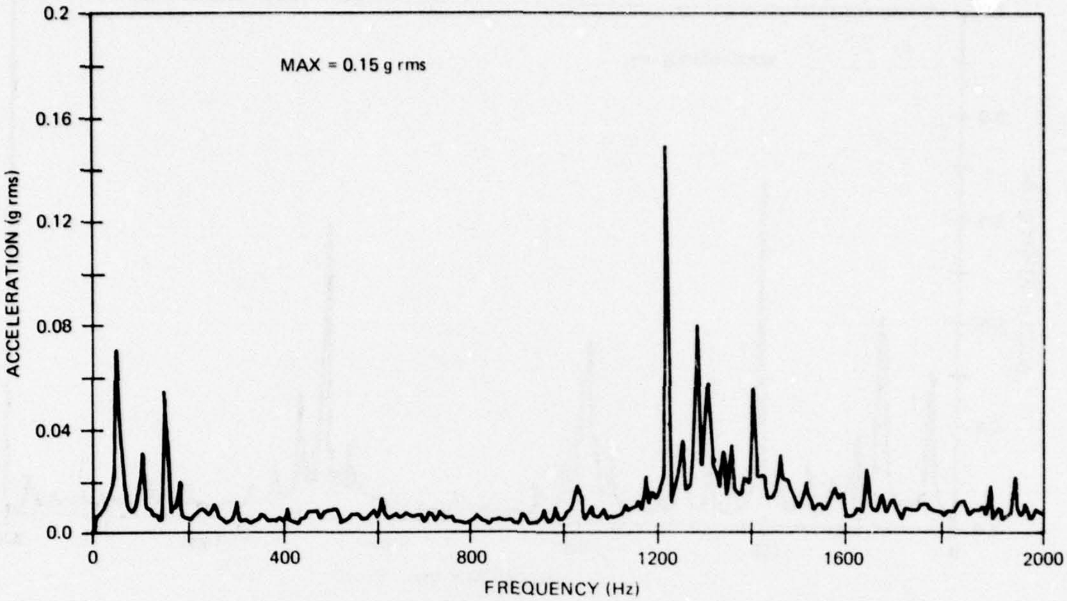


Figure C-1. Acceleration on Bearing Housing With Only the Blower Operating



NOTE: THE OVERALL g LEVEL WAS 0.4 g PEAK (0.28 g rms)

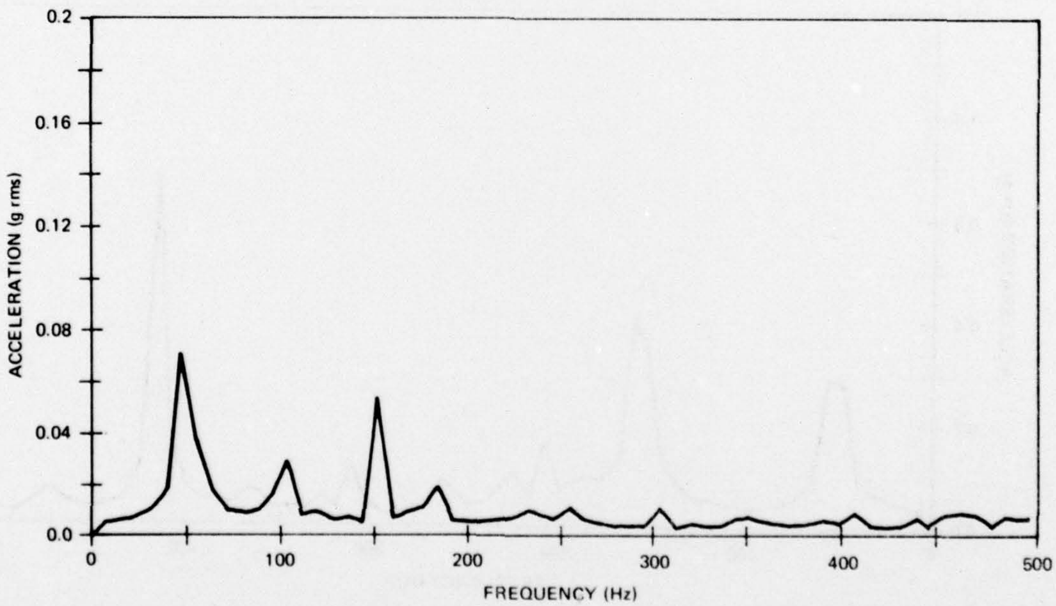
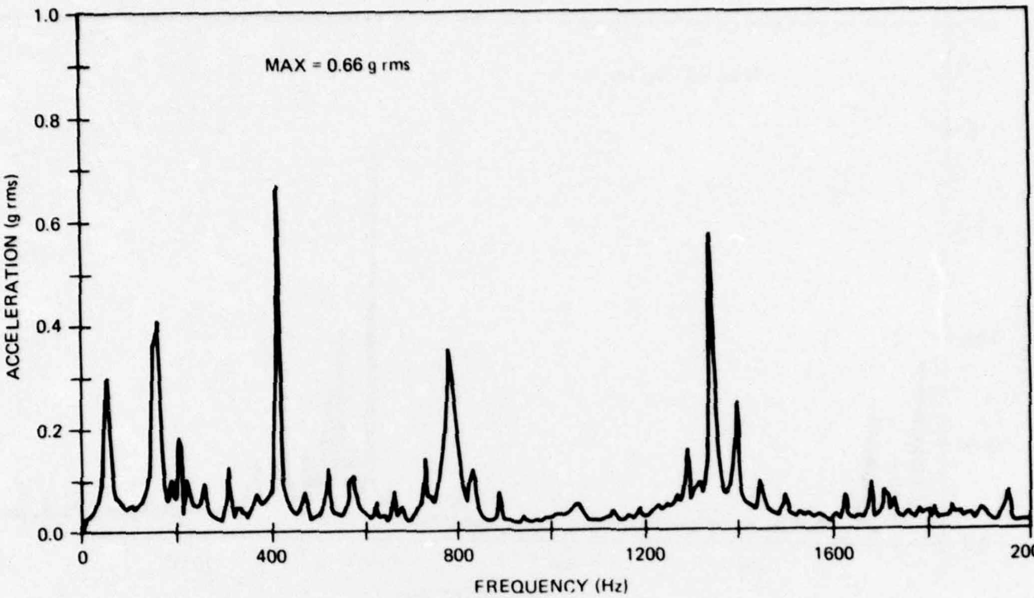


Figure C-2. Acceleration on Right Front Motor Mount With Only the Blower Operating



NOTE: THE OVERALL g LEVEL WAS 3.0 g PEAK (2.12 g rms)

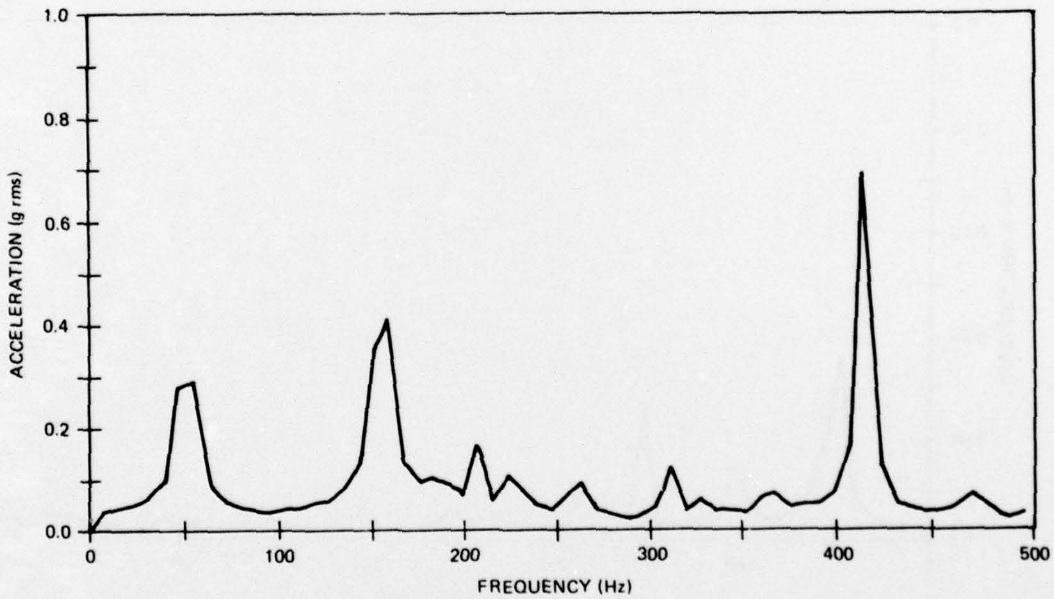
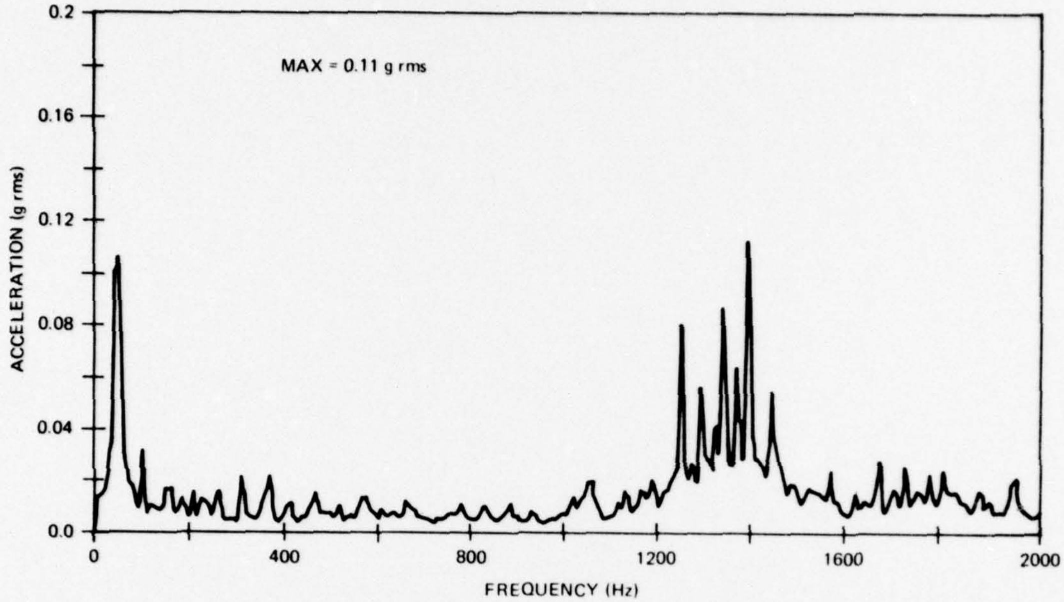


Figure C-3. Acceleration on the Bearing Housing With the Incinerator in Full Operation



NOTE: THE OVERALL g LEVEL WAS 0.5 g PEAK (0.35 g rms)

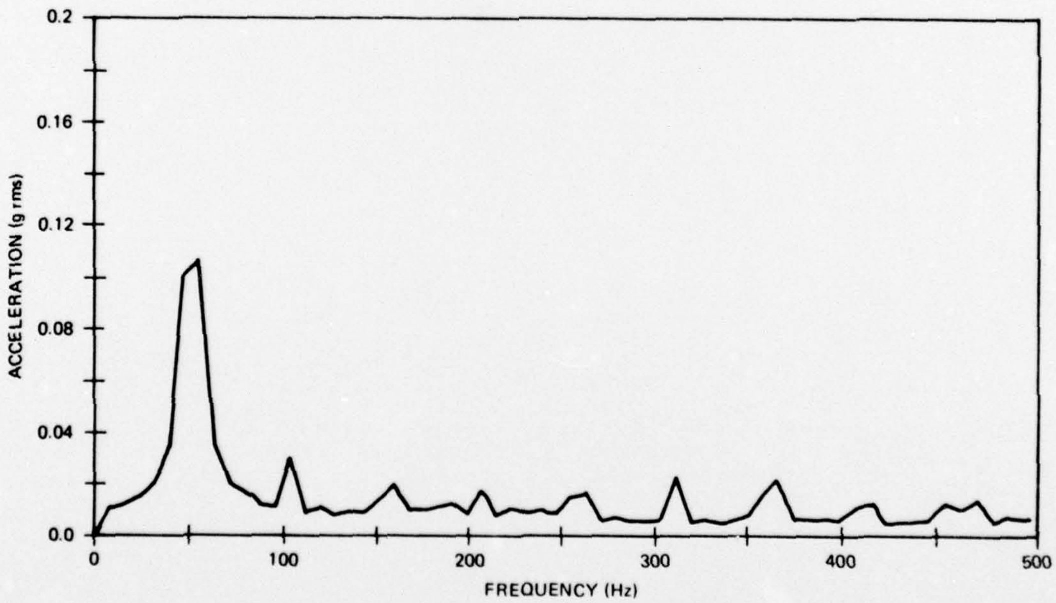


Figure C-4. Acceleration on the Right Front Motor Mount With Incinerator in Full Operation

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